BATTERY SAFETY SYSTEM IN ENERGY LOAD USAGE OF ELECTRIC CAR

Ahmad Hafiz Wijanarko[1)], Selamat Muslimin[2)], Ekawati Prihatini[3)]

[1)]*Student ofPublic Sector Accounting Study Program*
Email : ahmadhafiz17@gmail.com

[2)]*Lecturer ofElectrical Engineering Study Program, Politeknik Negeri Sriwijaya*
Email :selametmuslimin@gmail.com

[3)]*Lecturer ofApplied Science Electrical Engineering Study Program, Politeknik Negeri Sriwijaya*
Email : ekameiyer@gmail.com[3]

Abstract. Battery Safety system in energy load usage of electric car with current sensor ACS 712 as measure continuous flow on accu voltage divider and voltage sensor to measure to the level of the voltage on the sensors, both accu serves to measure the capacity of energy used and stored on the accu. The method used is to conduct research and utilize data to accu capacity in energy capacity on electric cars. On the tools side, there is a security detector device accu as an energy source in electric cars, according to the current sensor value ACS712 and circuit Voltage Diveder that serves to provide an analog voltage signal as signal data input into Microcontroller ATMega32 that serves to convert that data into the energy management system. The ATMega32 microcontroller is used as a data processing unit that will do data processing process voltage and current continuously while being given a burden. The results obtained is to give an indication of the form of the alarm using a buzzer when the conditions of energy at electric cars under level 50%. then decide and connect the load BLDC Motor via Relays burden on electric car if the battery is not sufficient energy capacity required electric car.

Keywords: Energy, Voltage Divider, sensorACS712

I. INTRODUCTION

The electric car is a vehicle with no emissions which becomes an alternative to reduce the number of air pollution. Just like oil-fueled cars, electric cars are also equipped with an indicator panel that serves as an important information tool for the driver to determine the condition of the vehicle directly when driving so that drivers feel comfortable and safe and can act quickly and correctly when something happens to their vehicle, for example, to know the speed of the vehicle, the battery capacity indicator, the distance that can still be reached, the temperature of the motor, the main lights indicator, turn signal lights, and other indicators. According to British Petroleum Chief Executive Officer, Tony Hayward, the oil reserves on earth would last only for another 42 years. One of the things that triggers the manufacture of electric car is its environmentally friendly properties and does not polluting the outdoors and can decrease the use of oil (BBM) which is diminishing over time. Most of the electric cars are created and developed by renowned car manufacturers outside of Indonesia, and has been widely used by people. Electric cars with solar cell can be combined with electronic components that have an important role in the testing as well as its use and purpose, one of them is the sensors used and the circuits used for separating or charger selector as desired.

In order to work the way we want, an electric car should have some systems, be it the mechanical systems as well as electronic systems. Mechanical system is a system associated with the chassis, gas and braking systems, as well as steering system. Electronic system is a system associated with the electric motor, monitoring sensors, and charger selection in the electric car.

A design of a vehicle cannot be separated from the vehicle energy management in order to save power consumption when the car works. Therefore in this study will be discussed how to design and apply good energy management system on the electric car so it has advantages in power consumption as compared to other cars.

The electric car is a car driven by a DC electric motor, using electrical energy stored in the battery or energy storage (Wikipedia.org). Electric car has several advantages compared to oil-fueled cars in general. The main thing is the electric car produces no air pollution. In addition, electric cars also reduce the greenhouse effect because it does not require fossil fuels as its main driving force.

II. LITERATURE REVIEW

Microcontroller ATMega32.

Microcontroller, as a microcontroller and microcomputer technology breakthrough, present to meet market needs and new technologies. As a new technology, the semiconductor technology containing more transistors, but only requires a small space and can be mass produced (in quantity) so the price becomes cheaper (compared to microprocessor). As the needs of the market, the microcontroller present tomeet the tastes of the consumer industry needs or desires aids and more sophisticated toys. Microcontroller ATMega32 is one of the family of MCS-51 family, a product of Atmel.

This type of microcontroller in principle be used to process data per bit or 8 bits simultaneously. In principle, the microcontroller program is run in stages. So in the program itself, there are several sets of instructions and each instruction was executed gradually or sequentially.

Microcontroller ATMega32 Characteristics.

Some of the facilities are owned by Microcontroller ATMega32 are as follows:
An 8 bits Central Processing Unit.

- Oscillator: Internal and timer circuit.
- 128 bytes of internal RAM.
- Flash Memory 2 Kbyte.
- Five interrupt lines (two external interrupts and three internal interrupts).
- Four Programmable I / O ports that each consisting of eight channels of I / O.
- A serial port with serial control Full Duplex UART.
- The ability to carry out arithmetic and logic operations. The rate in carrying out the instruction per cycle is 1 microsecond at a frequency of 12 MHz.

Microcontroller ATMega32 requires only three additional capacitor, one resistor and one crystals and 5 Volt power supply. 10 micro-Farad capacitor and 10 KΩ resistor is used to form a reset circuit. With this ATMega32 reset circuit, the circuit will automatically reset once it receives power supply. Crystals with a maximum frequency of 24 MHz and 30 pF capacitor is used to complete Oscillator circuit which form the clock that determine the speed of microcontroller. Memory is a very important part in microcontroller. Microcontroller has two kinds of memory with different properties. Read Only Memory (ROM) whose content will not change despite the loss of power supply on IC. In accordance with its needs, in the arrangement of MCS-51, program storage memory is named as the program memory.

ATMega32 has six interrupt generation sources, two of them are fed to the interrupt signal INT0 and INT1 feet. Both of these legs coincide with P3.2 and P3.3 thus cannot be used as a parallel input / output if INT0 and INT1 are used to receive an interrupt signal. ATmega32 is a type of AVR that has been equipped with 8 internal ADC channels with 10 bit fidelity. In this mode of operation, ATmega32 ADC can be configured either as a single-ended input or the Differential input. In addition, the ATmega32 ADC has the configuration of timing, voltage reference, operating mode, and extremely flexible ability to filter noise, thus easily adapted to the needs of the ADC itself. Port1 and 2, UART, Timer 0, Timer 1 and other means is a register that physically is a special RAM, which is placed in the Special Function Register (SFR). Description of the pins on the microcontroller ATMega32:

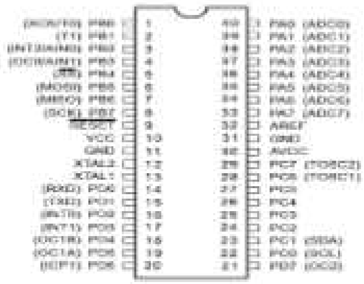

Fig.1 Configuration IC Microcontroller ATMega32 (source : Nugraha, Dhani dkk.2011)

Pin Explanation:

VCC : Voltage Supply (5 volt)
GND : Ground
RESET: Reset input a low level on this pin for longer than the minimum pulse length will generate a reset, although the clock is running.
XTAL1: The inverting oscillator amplifier input and the internal clock operating circuit input.
XTAL2: The output of inverting oscillator amplifier.
AVCC : Voltage supply pin to port A and ADC. This pin must be connected to VCC even if the ADC is not used, thus this pin should be connected to VCC through the Low Pass Filter.
AREF: Analog voltage reference pin for ADC.

a. Port A (PA0-PA7)
Port A serves as an analog input to the ADC. Port A can also serve as I / O Port 8-bit Bidirectional, if the ADC is not used, the port can provide internal Pull-Up resistor (selected for each bit).
b. PORTB (PB0-PB7). Port B is an I / O 8 bits Bidirectional with internal Pull-Up resistor (selected for each bit).
c. Port C (PC0-PC7). Port C is an I / O 8 bits Bidirectional with internal Pull-Up resistor (selected for each bit).
d. Port D (PC0-PD7). Port C is an I / O 8 bits Bidirectional with internal Pull-Up resistor (selected for each bit).

Electric Motors BLDC (800 Watt 48VDC).

Direct current motor is a motor that requires a dc voltage to run. In general, this type of motor uses brushes and is very easy to operate, just simply connect the motor to the battery thus the motor will rotate instantly. These motor types require maintenance on the brushes and a lot of voltage losses occur on the brush. So that in this era, DC motor is developed without using brush known as the BLDC Motor (Brush Less Direct Current Motor). This motor is chosen due to the high efficiency, smooth voice, compact size, high reliability and low maintenance. This motor is preferred for many applications, but most of them require control without censorship. The operation of BLDC motors require rotor position sensor to control the current.

BLDC motor is equivalent to DC motor with commutator reversed, where the magnet rotates while the conductor remained silent. In the DC motor commutator, the polarity is altered by the commutator and brushes. However, in Brushless DC motor, polarity reversal performed by switching transistors to synchronize with rotor position. Therefore, BLDC motors often incorporate either internal or external position sensor to sense the actual rotor position, or the position can be detected without sensors (Leonard N. Elevich,2005).

Fig.2 BLDC motor construction


Fig.3 Motor Brushless DC

Relay is a magnetic switch that is controlled by electrical currents. Relay connects the load circuit ON and OFF by giving electromagnetic energy, which opens or closes the contact on the circuit. (Frank D. Petruzella, 2001).

Relay has a low voltage coil wrapped around a core. There is an iron armature will be attracted to the core when current flows through the coil. The armature is mounted on a spring-loaded lever. when the armature interested, contact path together will change the position of the contacts are normally closed to normally open contacts.


Fig. 5 Relay

Current Sensor ACS712. ACS712 is a current sensor that works based on field effect. Current sensor can be used to measure AC or DC current. The sensor module has been equipped with operational amplifier circuit, thereby increasing the current measurement sensitivity and can measure a small current change. These sensors are used in applications in industrial, commercial, and communications. Applications example includes sensors for motor control, detection and use of power management, sensors for switch connected power supply, protection against overcurrent sensor, and so forth.

The following are the characteristics of the ACS712 current sensors:

- Has analog signals with low interference signals (low-noise)
- Has 80 kHz Bandwidth
- Total error output of 1.5% at Ta = 25^{o}C
- Has internal resistance of 1.2 mΩ
- 5.0V single operation supply voltage
- Output sensitivity: 66 up to 185 mV / A
- The output voltage is proportional to the AC or DC current
- Fabrication Calibration
- Highly stable output offset voltage
- Hysteresis due to the magnetic field close to zero
- The ratio of the output voltage is corresponding to its input voltage


Fig.7 IC ACS712

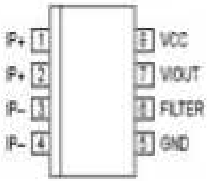

Fig.6 Configuration pin IC ACS712

Table 1 shows the configuration of each of each pin on the IC ACS712 and its functions.

Table 1 shows the configuration of each of each pin on the IC ACS712

ACS712 Sensor Pin	Function
IP+	Terminal which detects the current, there is a fuse in it
IP-	Terminal which detects the current, there is a fuse in it
GND	Ground signal terminal
FILTER	Terminal for external capacitor which serves a barrier bandwidth
Vlout	Analog signal output terminal
Vcc	Power supply input terminal

At the moment no current is detected, the sensor output is 2.5 V, when current flows from IP + to IP-, then the output > 2,5V while when an electric current in reverse flows from IP + to IP-, then the output will be <2.5 V. Here is a graph comparing the voltage the output of the electric current.

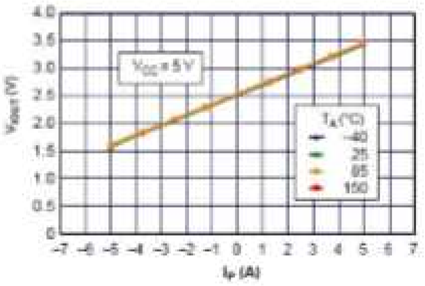

Fig.7 Charts ACS712 sensor output voltage to electric current

Voltage Divider. Voltage divider circuit is usually used to create a reference voltage from a larger source voltage, a reference voltage point on the sensor, to provide a bias to the amplifier circuit or to give a bias to the active component. A voltage divider circuit can basically made with two resistors, an example of a basic circuit with a voltage divider output of the voltage source VO VI using voltage divider resistors R1 and R2 as shown below.

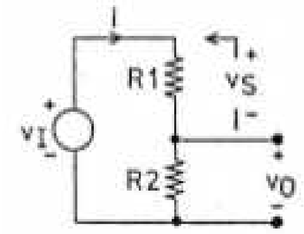

Fig.8 Circuit voltage divider

The output voltage (Vo) of the voltage divider circuit above can be formulated. Current (I) flowing in the R1 and R2 so that the value of the voltage source VI is the addition Vs and Vo can be formulated.

$$VI = Vs + Vo = i \cdot R1 + i \cdot R2$$

The input voltage is divided into two parts, each rated voltage proportional to the value of the resistor is subjected to voltage. So that the magnitude Vo formulated as follows.

$$Vo = ViVo = Vi\left(\frac{R2}{R1+R2}\right)$$

Figure 10 the voltage divider circuit shows a voltage divider with a load attached at the output, taking current io and voltage drop of vo.

III. RESEARCH METHODS

Planning System. Block diagram is one of the most important, because with the block diagram can be seen the workings of the entire circuit is used. So that the block diagram of the circuit will produce a system that can be enabled to work in accordance with the design.

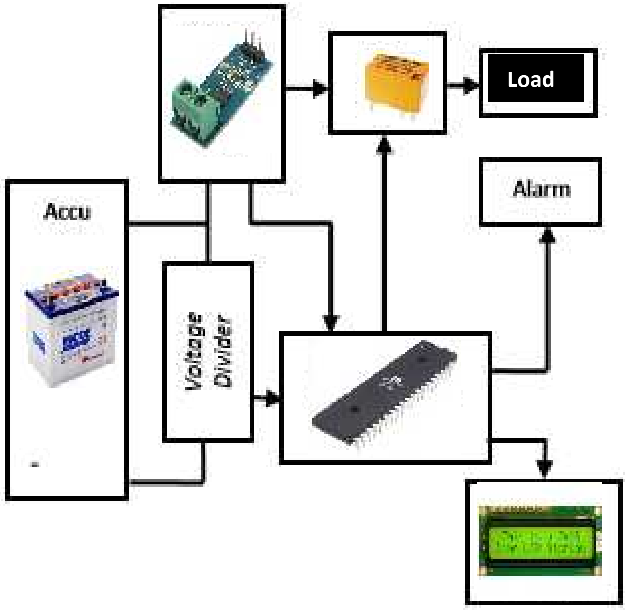

Fig.10 Block diagram of the energy in the battery system

Electronic Design. There are electronic circuit has a schematic circuit that will be used in solar cell electric car.

Regulator circuit. Regulator circuit serves to lower large voltage from batteries into the low voltage source is $24V_{DC}$ and $12\ V_{DC}$. The working principle of the circuit as same as the power supply, that has three important parts: transformer, rectifier, condenser as a low pass filter and an electronic regulation. Accumulator in this series is like a transformer as an input circuit has a large enough voltage of $48V_{DC}$.

Voltage of $48\ V_{DC}$ and a current of 40 AH of splicing Accumulator 12V 40 AH are assembled in series to get the voltage value of 48V. BLDC motors with a working voltage of 48 VDC and a current of 40 AH according to the data sheet, it can be regulated by the microcontroller 5 VDC.

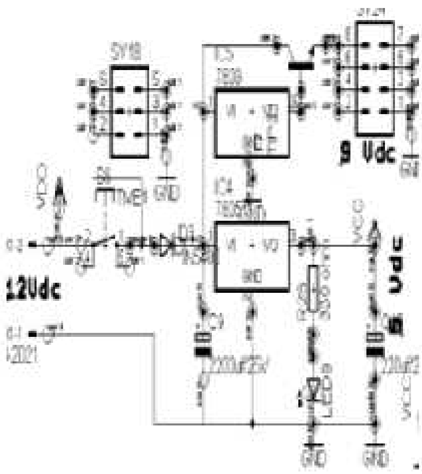

Fig.11 Power supply circuit ATMega32

Figure 11 is a schematic circuit of the power supply with the output consists of three DC outputs, namely: 5 VDC which is used as a voltage source to the circuit minimum system ATMega32, 12 V as a voltage source relay load, minimum system and PNP transistor. the BLDC motor as the driving electric cars SOLARCELL, to output 9 V processes that will be used hereinafter, 9VDC as a backup input.

Minimum System Circuit ATMega32

Minimum System ATMega32 circuit has an input voltage of 5 V. Microcontroller can be used to process data per bit or 8 bits simultaneously. Minimum System Usage ATMega32 receives analog voltage signals of ACS712 current sensor and sensor divider.

Flow Sensor Socket circuit ACS712

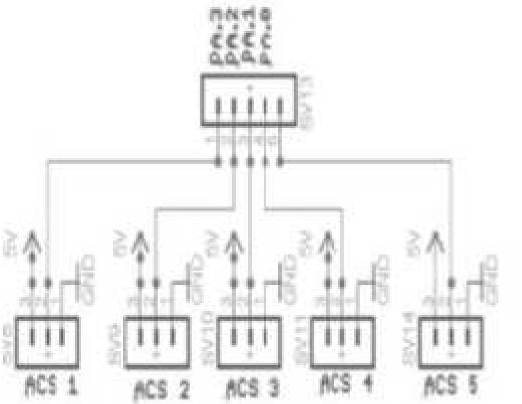

Fig.12 The series of 5 pieces ACS712 current sensor socket

Figure 12 shows a series ACS712 current sensor module socket has three pieces of pin that is + 5V, Signal, and Ground. pin + 5V on this circuit is connected to the power supply of 5V regulator minimum system ATMega32. Pin signal on this circuit is connected to the four ports on the system ADC minimum. Then the second sensor is a voltage sensor, Voltage Divider.

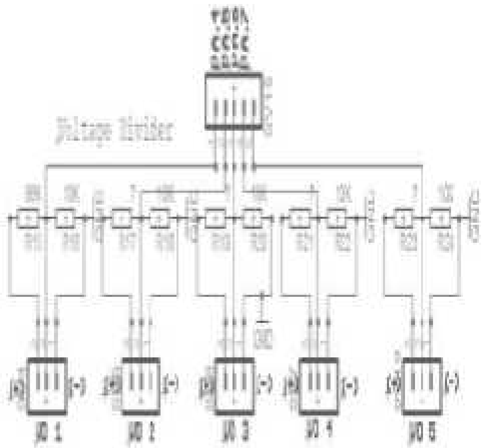

Fig.13 Five Voltage sensor sockets voltage divider

Figure.13 Five voltage sensor sockets voltage divider consisting of 2 resistors as a voltage divider which will be measured at the input leg positive (+) and negative (-), an analog voltage signal in the circuit produces a maximum voltage of 5VDC as a data input analog voltage to the to the ADC port on the system minimum ATMega32 result V_{out} of the two types of sensors will be processed according to the calculation formula using the program BASCOM AVR and the output of the minimum system are in the form of lcd 16x2 which will display data calculation of energy and generates a signal logic function activates and disconnect relay 12 VDC PNP transistors 30A with the help of a trigger input 557 is 12 VDC.

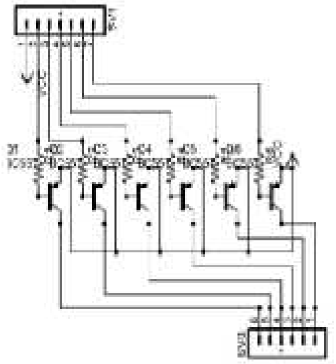

Fig.14 Transistor circuit

Picture 14 and 16 are integrated functionally as the movement trigger with BLDC Motor with 48VDC/40AH input as the load. The data sent as logic data from ATMega32 microcontroller to the collector and the emitter get 12 VDC voltage and the base given negative voltage as the truth table of transistor PNP BC 557. After transistor work then the relay will receive the logic data and connect the BLCD motor.

Mechanical Design. Charging system in the electric car that functioned to re-charged the accumulator that used when the car work. There are 2 ways in charging an Accumulator, they're with solar cell and with 220 AC Voltage.

The figure below is a mechanical design of electric car charging system.

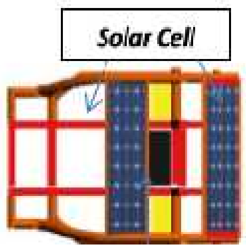

Fig.15 The charging system

IV. RESULT AND DISCUSSION

The result of the test can be seen with this table.

Tabel.2 Accu Voltage Measurement 48 / 32Ah using a voltage divider

No.	**Measuring Instrument (V)**	
	Accu	**Voltage divider**Capacity X (%) **V**out ADC = 1023

1.	55V	5	1023	100
2.	54V	4.9	1003	100
3.	53V	4.8	983	100
4.	52V	4.7	962	100
5.	51V	4.6	943	50
6.	50V	4.5	921	37
7.	49V	4.4	901	25
8.	48V	4.3	880	12
9.	47V	4.2	860	0

From the Table 2 the measurement of voltage variation in accumulator 48V/Ah. In the voltage divider circuit that used as sensor to measure the voltage in energy management system. Voltage divider produce converted output voltage to microcontroller in the maximum limit 5V with 2 resistor that designed series, charging or there is voltage in the accumulator cell. But, the normal voltage for full condition accumulator is 52V. So 55V voltage divider is used to give the toleration so the converted output voltage is not bigger than 5V so it’s not break the microcontroller, using the voltage divider formula the resistor value can be adjusted, the first resistor is 100K Ohm and the second resistor is 10K Ohm. So the voltage divider can produce the maximum voltage as big as 5V when detected the maximum voltage as big as 55V that will be continued to the microcontroller in the ADC PORTA2 pin. When the battery in 100% condition show 52 V or 55 V and when it’s in low condition it shows 47V. 55V will be detected when 4 accumulator assembled in series just charged or surface tension at the battery cells (Charging Surface). However, the normal stress conditions for 52V batteries are full. So for voltage of 55-52 V battery capacity will be read as 100% due to surface charger tension. Range is used to measure the battery capacity is 55 V-47 V = 8V. The difference between a full battery and a weak battery is 8 V. This difference will be divided by 100%, thus $\frac{8V}{100\%}$= 0.8 V. For every increase of 1% then an increase in the voltage of 0.8 V whereas, for the conversion of voltage signal Vout of voltage divider into percentages on the microcontroller is with the following formula:

100% = Vin (ADC) – 860
= 1024 – 860 = 164
=164 – 64 = 100%

Explanation:
Vin (max) = 55V
Vout (max) = 5V ,
Vout (max)ADC = 1023

Vin (min) = 47V
Vout (min) = 4.2V
Vout (max)ADC = 860
ΔVout (ADC) = Vout(max) – Vout(min)
= 5 – 4.2 = 0.8
Thus,an increase of 0.8 volts at every increase of 1%

Table.3 Load currentwith ACS712 30A

Load (A)				
No	**Load A**	**ACS712 31A**		
		Vout	ADC = $\underline{V_{in}}$ x V_{out}	Conversion (A)
1	0	2.5	512	0
2	1	2.6	548	1
3	2	2.7	585	2
4	3	2.8	573	3
5	4	2.9	593	4
6	5	3.0	614	5
7	6	3.1	634	6
8	7	3.2	655	7
9	8	3.3	675	8
10	9	3.4	696	9
11	10	3.5	712	10
12	11	3.6	737	11
13	12	3.7	757	12
14	13	3.8	778	13
15	14	3.9	798	14
16	15	4.0	819	15
17	16	4.1	839	16
18	17	4.2	860	17
19	18	4.3	880	18
20	19	4.4	901	19
21	20	4.5	921	20

From the results of Table 3 is the data conversion value of the output voltage signal 30A ACS712 current sensor. 30A ACS712 sensors work on the voltage of 5V can generate voltage V_{out} from 2.5 to 0A to 30A and 5V. In the test data ACS712 current sensor 30A is operated only current measurement up to 20A continuous load due to the use of energy management systems across the maximum load on the electric car approximately 20A. From the measurement data of Table 5 ACS712 / 30A changes increase the output voltage signal V_{out} to the continue load. Namely an increase in the output voltage signal is proportional to the increase in the loads measured.

To view conversion data continuous current, the output voltage Vout at the foot of the ACS712 current sensor connected to the microcontroller pin ADC on PORTA.0 converted into data ADC values, for current 0A to the output voltage is 2.5V Data ADCnya 512. By using the formula:

Continue Current = $\frac{ADC\,\Delta Vout - ADC\,2.5V}{0.08V}$

Explanation:
0.08 V = the value of any increase in voltage V_{out} 1A obtained from the formula ÷ 2.5V 30A = 0.083 V = (16.9 ADC).

Accumulator Energy Management Measurement

Table.4 Accu energy consumption on 42.48 minute sample with 30km/h speed

No	Load (A)	Km/H	Time Usage (Minute)	Teg (V)	Current (A)	Information (%)	Status	Indication
1	19.6	30	95.58	55	32	100	H	Surface Charging
2	19.6		84.96	54.7				
3	19.6		74.34	53.6				
4	19.6		63.72	52.5				Normal
5	19.6		53.10	51.4	16	50	M	
6	19.6		42.48	50.3	12	37.5		Alarm
7	19.6		31.86	49.2	8	25		
8	3		21.24	48.1	4	12.5	L	Discharge
9	3		10.62	47	3	0		

From the data in Table 4 measurement of the overall management of energy consumption on a car battery electricity were taken from a sample of using the maximum speed of the electric car of 30 Km / H. From the description of the data at a maximum speed measured continuous load current of 19.6A comprising electronic load and mechanical load. Electronic load such as system monitoring, relay unit, ACS712, optocoupler, seven segment, and bluetooth HC-06 using the maximum current load of 3A and inductive load of the motor plus a maximum of 16.6A. in order to get maximum load current of 19.6A. for the current state of battery voltage just finished di-charging has become 55V voltage charging surface and to a normal state when the batteries full, or when the capacity of 100% at 52.5V voltage at 48V batteries.

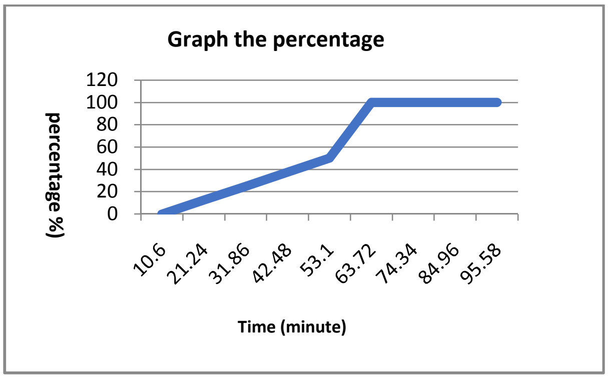

Fig.16Battery capacity percentage graph toward the duration (*lifetime*)

In figure 16 describes the graph about the length of usage time in minutes to the percentage of battery capacity (%). From the graph above it can be seen that the percentage of 100% battery capacity of the car can be run with the maximum current load or at a speed of 30 Km / H in a time of 95.58 minutes or 1:35 hours.

Of all the measurement data is carried out, an energy management system has an important role in electric cars. Energy management system serves to determine the continuous flow using ACS712 current sensor mounted on the positive output 48 V batteries to be connected to the load on the electric car. ACS712 output signal V_{out} will be converted into amperes through the minimum system ATMega32 on ADC pin PORTA.0 thus measurable continuous stream when the car is turned on and running. An energy management system is used to measure the capacity of the battery energy level into the percent (%) using the voltage sensor voltage divider, V_{out} has been converted using the ATmega32 minimum system POTRA.1 ADC pin. of energy capacity can be measured using the Voltage divider. Alarm indicator which will sound in order to remind the driver that the energy in the accumulator of an electric car is below 40%. Then the second is the output termination and connection relay automatically load when the battery energy level conditions on the electric car is less than 15%. It aims to provide security to the batteries in order to avoid voltage drop that causes damage to the battery when the car is still running when the batteries in electric cars is almost gone

V. CONCLUSION

Based on the analysis results, we can conclude that:

1. Accumulator conditions on the electric car is 100% state (High) Indication of Surface Charging, 37,5% - 50% status (Middle) and Alarm Indication Normal, and 25% state (Low) Discharge Indicator
2. With the use of batteries 48V 32A that are arranged in series on the electric car can run at a maximum speed for 95.58 minutes. The maximum load current used in electric cars is 19.6 A.
3. The design of the load relay automatic energy management system aims to provide security to the batteries in order to avoid voltage drop that causes damage to the battery when the car is still running when the batteries in electric cars is almost gone

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