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Developing portable variable power supply with wireless port

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Abstract: The advancement of technology nowadays inspires peoples to create miniaturized electrical and electronic products to emerge the requirement of user. Many existing power supply give single DC output and need electric supply. This project is to develop a Portable Variable Power Supply (PVPS). The aim of this project is to build portable power supply that can be used anywhere whenever there is no present of electric supply which needed by conventional DC power supply used in laboratory. PVPS is suitable to be used electronic equipment testing and repair which useful for EE302 Electronic Equipment Repair, EE501 Project 1 and EE601 Project 2 subjects in Electronic based engineering courses for all Polytechnics. Also, Malaysia is a developing country and a lot of new invention or innovation is needed to support developing activities. According to 10th Malaysia Plan, government will support innovation by creating an environment in which all individuals are able to engage in innovative activity (Economic Planning, 2010). PVPS is innovated to support site activities that related to electronic field.

Key words: Portable power supply; DC power supply; Variable power supply

1. Introduction

Kementerian Pelajaran Malaysia (KPM) had introduced curriculum for Electronic Equipment Repair and Project 1, Project 2 since 2012. In order to makes teaching and learning process more effective, the cost to prepare and maintain the equipment at Electrical Engineering Department out of budget most of the time. The variable power supply used in laboratory of Electrical Engineering Department, Mukah Polytechnic cost RM1500 per set and aged of ten years and yet, only can be used in laboratory which electric supply achievable. Hence, a new type of teaching aid equipment is needed.

Also, considering used of power supply at electrical and electronic industries, a Portable Variable Power Supply (PVPS) is developed in order to fulfill the requirement of equipment used in teaching and learning process and used in industries.

This report describe the design of a portable power supply capable of providing 3A, 1.2V to 10V adjustable DC supply port for variable range of electronic circuit testing and repair, and a 3A, fixed 5Vcontinuous DC supply port for semiconductor based circuit used. Also, there is wireless port to use with built-in wireless power receiver breadboard. Li-ion batteries are installed in the PVPS to support the whole system. However, the system parameters may be changed to optimize performance depending on type of batteries used for example NiMH, NiCd, SLA,Li-ion and Lipo.

The PVPS supply maximum of 9V is set because most of the circuitries and embedded system operate at low voltage and applicable for most of electronic industries (Jason et al., 2006). Also, the system of PVPS is using linear regulator to provide stable voltage output to provide consistent operation of circuitries (Joshua, 2009).

2. Problem Statement

Firstly, Electrical Engineering Department of Mukah Polytechnic needs more power supply to support teaching and learning process specially subjects that related to measurement, repair, and testing.

Secondly, the conventional power supply can only be used at the place with electricity supply. User facing difficulty to do testing and repairing work at place without electricity supply.

Thirdly, the existing DC power supply is expensive and provide only adjustable power port which need wire connection.

3. Objective

This project is to develop a portable variable power supply to help in not only teaching and learning process, but also to support industry used. The objectives of this project are:

- Develop a portable power supply with aid of rechargeable battery.
- Built an adjustable linear power supply circuit that provides stable output and install wireless port to simplify testing work.

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- Built a 5V regulated supply for semiconductor based circuit testing.

4. Significance of project

By developing this project, PVPS can support the lecturers in Polytechnic in running practical works. With a simple but efficient PVPS, teaching and learning process can be done at any place other than in laboratory. Also, this saving lots of time for students to waiting turn to use limited set of power supply.

With aid of PVPS, students can engage in more practical skills in EE302 Electronic Equipment Repair, EE501 Project 1 and EE601 Project 2 subjects in Electronic based engineering courses.

Other than that, PVPS also applicable to be used in supporting electronic industries such as testing and repairing work.

5. Project scope

The scopes of project are as below:
This project is mainly used for electronic and electrical based course.
Other than that, PVPS also can be used for repair and testing purpose in low voltage electronic industries.
PVPS can supply a single adjustable output range from 1.2V – 10V, a 5V fixed voltage output and a wireless 12.3V port.
Circuit printed on single layer PCB.
This project is using 3 pieces 4.2V Li-ion battery.
PVPS is charged through 12V 1A external charger and the charging interval is rated at 3 – 3.5 hours.

6. Methodology

The linear power supply has been widely used by industry for a very long time until switching power supply invented after 1960's. Linear power supply is simple to develop and easy to use.

Linear power supply has better noise elimination compare to switching power supply. The comparison chart between linear mode and switching mode are shown in Fig. 1 and Fig. 2 respectively. The advantage of using linear mode have low voltage ripple and fast transient response compare to switching mode However, supply efficiency of linear power supply is usually low when output voltage is much lower than input voltage (Henry, 2013).

PVPS is using linear mode of conversion because stable output is needed to test sensitive electronic circuits or equipment. Also, regulate voltage from battery supply of 12.6V li-ion batteries (3x4.2V) to 5V and 10V do not affect much on the efficiency since there is not much voltage different the input and output.

Type of battery used in PVPS is considered in order to fully utilize the space of the casing. The electrical characteristics of battery define how it will perform in the circuit and the overall weight and size play important role in designing the casing of the system. There is various type of battery such as Ni-Cd, Ni-MH, Li-ion, SLA.

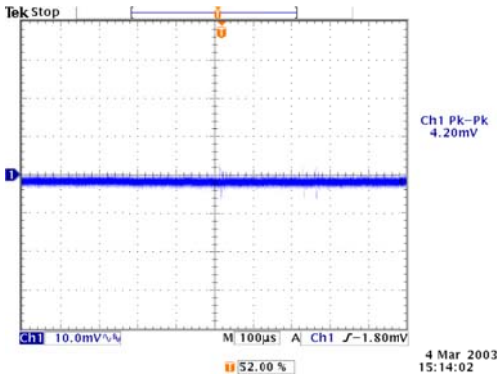

Fig. 1: Linear power supply (Lambda, 2003)

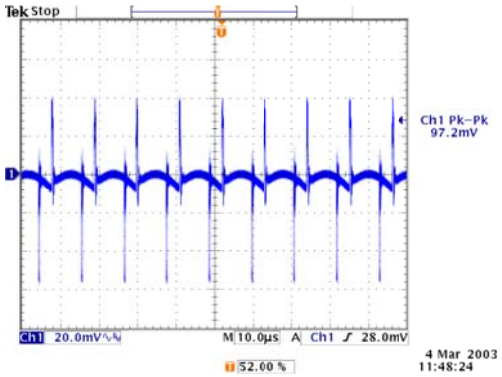

Fig. 2: Switching power supply (Lambda, 2003)

Lipo. Li-ion is chose to be used in PVPS because of its size and stability factor. Li-ion battery has higher volumetric energy density compare to other type of battery and stable discharge rate as shown in Fig. 3. Also, Li-ion battery have lower self-discharge rate than other type of battery which discharge at rate of 5% - 10% of full capacity per month (Chester, 2011).

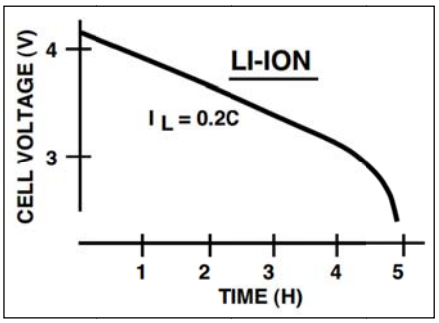

Fig. 3: Cell discharge curve (Chester, 2011)

The basic principle of wireless power transfer, WPT is that two self-resonators that have the same resonant frequency can transfer energy efficiently over mid-range distance. A magnetically coupled resonance WPT system uses an intermediate self-resonator coil to extend the coverage of wireless power transfer that is coaxially arranged with both transmitter and receiver's self-resonant coils (Hamam et.al., 2009).

The transmission medium is the free space. The coupling elements are using inductive coils as shown in Fig. 4 (Jan and Milos, 2011). On the side of source, a transmitter coil excites magnetic field in the determined space. The receiver coil, which can be moved in this space and power, is delivered to the load with the help of a receiver coil which coupled to the transmitter's magnetic field.

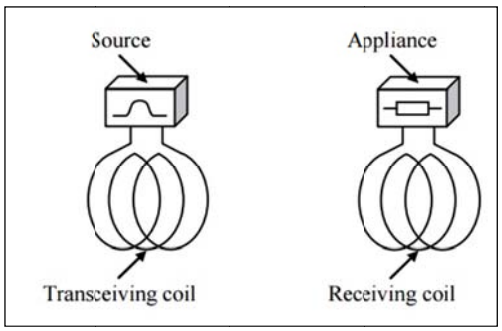

Fig. 4: Transmitter and receiver coil

Considering the ergonomic lifting factor, the dimension of the casing is chosen according to the size of the circuit and batteries and designed at optimal size of 20cm x 16cm x 9cm and the weight of PVPS is 450g not including the external charger which is at least ten times lighter than regular power supply unit.

The PCB of the circuit is drawn using PCB Wizard software application. This software application is a simple but yet sufficient to design single layer PCB layout.

7. Result and discussion

The PVPS is successfully developed and testing had been done. All the circuits work as expected which the adjustable output can be adjust through variable resistor from 1.2V to 10V. Fig. 5 below shows the main linear power supply circuit of PVPS. The circuit is protected by two stage fuse rate 10A placed at the incoming port between battery and the circuit and 1A fuse is place between LM317 voltage regulator and the pull up transistor to avoid voltage regulator over current.

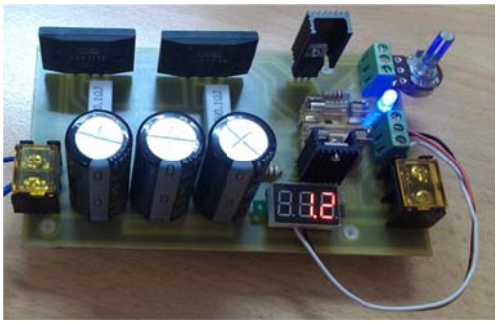

Fig. 5: Linear power supply circuit

The display of variable output port is tested to ensure the correctness. Fig. 6 shows the testing using of output port using multimeter. The seven segment display shows same reading as in multimeter. However, the seven segments display only display 1 decimal point. The output port is attached with diode to protect the circuit from short circuit during testing work.

Fig. 6: Testing with multimeter

The wireless port is on top of the PVPS and the breadboard is supplied when placed on top of the body of PVPS as shown in Fig. 7 and the maximum voltage can be supply by of wireless port reach 12.3V and this may very when different battery is installed. The breadboard received the highest supply when the transmitting and receiving coil is at the nearest distance. Hence, the breadboard only receives the supply when placed on top of PVPS where the transmitting coil is installed.

Fig. 7: Wireless breadboard on wireless port

Testing is done on the capacity of 3 pieces fully charged 4.2V 2600mAh battery using 2W high power LED rated at 3.2V 650mA last for 4 hours. Most semiconductor device drain small amount current and the battery estimated to last longer than 5 hours. The options of battery may change the system

attribute such as maximum current of output supply and operating time. More batteries can be added in parallel to the installed battery to increase the operating time and added in series to increase voltage the variable output port.

External charger is used to recharge the internal battery. Also, the charger can be connected for prolong used or whenever high current device is connected to PVPS as capacity of battery is limited due to weight and space consideration.

At this stage, the PVPS can only be charge using 12V external charger or 12V 1A rated adapter. When operate using 12V adapter, the output current of the PVPS is depending on the maximum current rate of adapter used.

The PVPS outlook is as shown in Fig. 8 with dimension stated in previews. PVPS can be turn ON and OFF by switching the switch installed at the left side of PVPS. Fix 5V and variable output port is place in the front together with the voltage supply display.

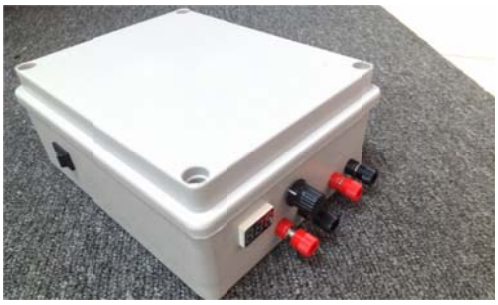

Fig. 8: outlook of PVPS

The cost of PVPS is divided into two parts which consist of circuit and casing which cost RM180.00 and the battery cost RM120.00. The total cost to develop this project is RM300.00. However, the total cost may vary according to the type of battery used.

8. Project limitation

This project is limited to operate at the DC voltage range of 1.2V to 10V and maximum current of 3A for variable output port and 12.3V for wireless port which supply throughout the maximum range of 1.5cm. Also, the operating time is limited since only 3 piece of battery is installed in PVPS due to space limitation.

9. Suggestion

There are few suggestions to be considered for the future development and improvement for PVPS such as:

- Includes AC 220V supply port for low power AC devices.
- Includes USB port for mobile phone charging purpose.
- Install solar panel to extend the use of PVPS at site.
- Adding handle for carrying purpose.
- Add more battery to prolong the operating time.

10. Conclusion

As conclusion, this project is successfully developed. Li-ion battery is chosen to be used in this project as this type of battery has lower self-discharge rate and smaller size.

An adjustable linear power supply provide consistence output and the voltage can be monitor from the seven segment display. The wireless output port able to supply consistent output at correct position and the fix 5V output port is very useful in low voltage testing activities.

PVPS is suitable to be used for practical works in teaching and learning process of Electronic Engineering courses.

Also, it should be useful in supporting repair and testing work of low voltage circuits which suitable to be used in low voltage industries.

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