Design and Construction of Power Supply for Embedded System

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Abstract **– In the present paper the Power Supply (PS) is designed and constructed for the microcontroller based Embedded System (ES). The microcontroller or digital based ES mostly required +5V/100mA regulated online UPS type power supply. This PS is especially designed for low power applications with less than 100mA. Most of the educational laboratory experiments, ES, Digital TTL based devices etc. needs +5V and current less than 100mA. The load characteristics and percentage of regulation for mains power ON and OFF conditions are found. The 3-terminal regulator IC is used.**

Keywords: **UPS, Power Supply, Embedded System, Regulation**

I. Introduction

Many digital circuits, microprocessor or microcontroller based ES are working with +5V D.C. power supply, but they have a major drawback, i.e. they can not be operated during power failure. In most of the ES the back up battery is used. This presented design is simple +5V D.C. regulated Uninterruptible Power Supply (UPS). The 3-pin regulator ICs are generally used for voltage regulation. The battery in UPS needs to charge by properly designed bridge rectifier [1]. The charger continuously supplies the DC bus with power and its power rating is required to meet 100% of the power demanded by the load as well as the power demanded for charging the battery bank [2,3].

The main types of the static UPS systems are: On-line, off-line, and line-interactive configurations. An ideal UPS should be able to deliver uninterrupted power while simultaneously providing the necessary power conditioning for the particular application. Comparing the three types of UPS systems (on-line, off-line, and line-interactive), the most expensive and less reliable are on-line UPS systems. In spite of these disadvantages, on-line UPS systems are irreplaceable in some applications. In applications that need the input electrical energy to be continuously provided, without any interruption, on-line UPS systems are the only one appropriate because their transit time is null [3].

List of Components

i. One Transformer 0-9V/500mA

ii. Four diodes 1N4007

iii. One electrolytic capacitor 1000µF/25V

iv. One chargeable battery 12V/4.5Ah

v. One regulator IC 7805

vi. One 0.1µF Box Type Capacitor

vii. Variable resistance box (or Potentiometer 0f 1K Ω)

viii. Few multimeters to measure current and voltage.

II. Circuit Understanding

The Figure 1 shows the circuit diagram of +5V UPS is connected with microcontroller based ES. In this circuit the function of the UPS can be easily understood. When the mains are on, the device gets power from mains and some part of mains are used to charge the battery. When the mains power is off, the device gets power from the battery. The output device remains on during both the conditions of mains power. The present setup is known as on line type PS for ES.

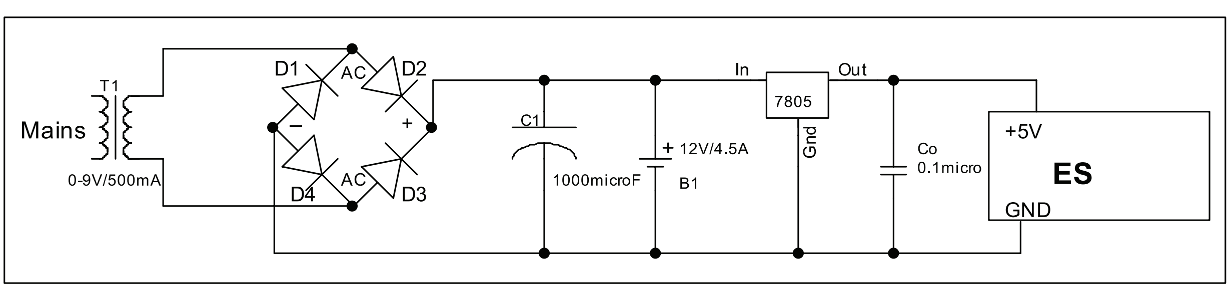

Fig.1 PS connected with ES

Figure 2 shows the experimental setup to take observations for the load characteristics. In the designed PS, the observations for power line on and power line off conditions are shown in Table I The load characteristics for mains ON and mains OFF are shown in Figure 3 and Figure 4 respectively.

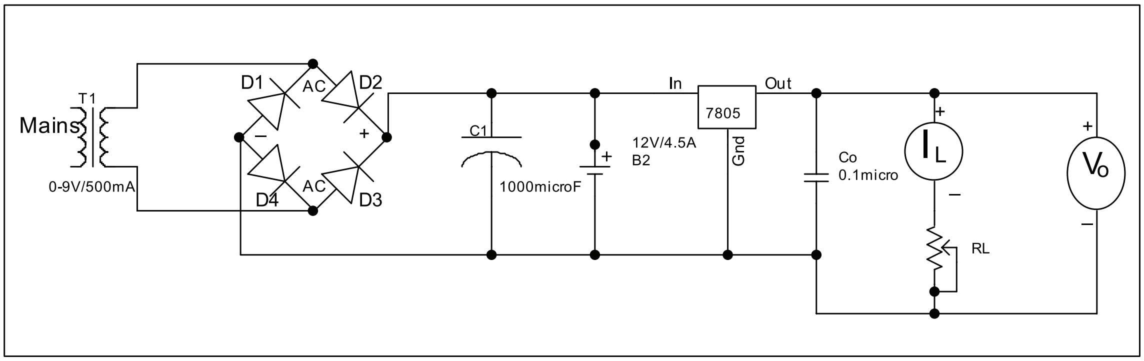

Fig.2 Experimental setup to obtain load characteristics of PS

TABLE I LOAD CHARACTERISTICS OF PS

Observation No.	Power line ON			Power line OFF		
	I_L (mA)	R_L Ω	V_o (Volt)	I_L (mA)	R_L Ω	V_o (Volt)
1	0 mA	α Ω	5.07 V (V_{NL})	0 mA	α Ω	5.06 V (V_{NL})
2	10 mA	560 Ω	5.06 V	10 mA	461 Ω	5.06 V
3	20 mA	300 Ω	5.04 V	20 mA	301 Ω	5.03 V
4	30 mA	211 Ω	5.03 V	30 mA	211 Ω	5.02 V
5	40 mA	167 Ω	4.96 V	40 mA	169 Ω	5.00 V
6	50 mA	142 Ω	4.94 V	50 mA	144 Ω	4.99 V
7	60 mA	124 Ω	4.94 V	60 mA	126 Ω	4.98 V
8	70 mA	111 Ω	4.93 V	70 mA	113 Ω	4.96 V
9	80 mA	101 Ω	4.93 V	80 mA	65 Ω	4.96 V
10	90 mA	58 Ω	4.92 V	90 mA	58 Ω	4.94 V
11	100 mA	52 Ω	4.91 V (V_{FL})	100 mA	52 Ω	4.93 V (V_{FL})

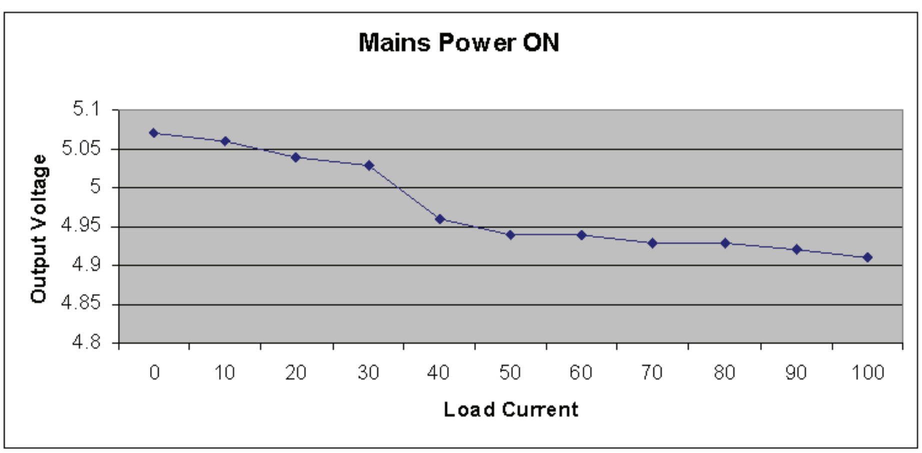

Fig.3 Mains power ON load characteristics

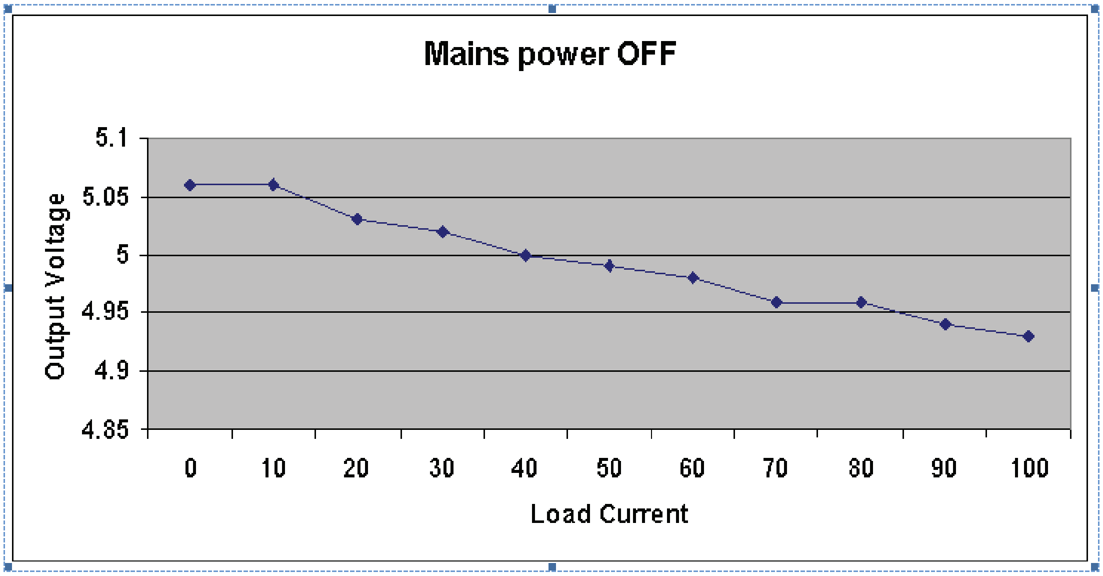

Fig.4 Mains power OFF load characteristics

Load Regulation

A commonly used figure of merit for a power supply is its percentage of regulation. The figure of merit gives us an indication of how much the output voltage changes over a range of load resistance values. The percent of regulation aids in the determination of the type of load regulation needed. Percent of regulation is determined by the equation - [1].

$$\%\text{ of Regulation} = \frac{V_N - V_E}{V_E} X100\% \qquad [1]$$

Mains Power On

$$\%\text{ of Regulation } = \frac{5.07 - 4.91}{4.91} = 3.26$$

Mains Power Off

$$\%\text{ of Regulation} = \frac{5.06 - 4.93}{4.93} = 2.637$$

III. Analysis and Discussion

Most of the microprocessor, microcontroller and digital circuits are working with D.C. +5 Volt. The load characteristics for the designed +5 volt D.C. regulated on-line type UPS is shown in Figure 3 and Figure 4. The graph in Figure 4 shows better regulation than graph in Figure 3. It means, the on line regulation is poor than off line regulation. The resultant percentage of regulation is proving the same. Generally, most of ESs need less than 100mA current. Suppose the off-line or line interactive type of UPS is designed, then it will reset the ES while switching to battery from power line failed.

The percentage of regulation is acceptable because most of the microprocessor, microcontrollers and digital devices can work efficiently in this range of voltages from 4.91V to 5.07V. The designed PS is tested by connecting it with microcontroller based Real time clock.

A battery with a capacity of 1 amp-hour should be able to continuously supply a current of 1 amp to a load for exactly 1 hour, or 2 amps for 1/2 hour, or 1/3 amp for 3 hours, etc., before becoming completely discharged. In an ideal battery, this relationship between continuous current and discharge time is stable and absolute, but real batteries don’t behave exactly as this simple linear formula would indicate. Therefore, when amp-hour capacity is given for a battery, it is specified at either a given current, given time, or assumed to be rated for a time period of 8 hours (if no limiting factor is given).

The amp-hour is a unit of battery energy capacity, equal to the amount of continuous current multiplied by the discharge time that a battery can supply before exhausting its internal store of chemical energy [5].

$$\text{Continuous current (in Amps)} = \frac{\text{Amp-hour rating}}{\text{Charge/discharge time (in hours)}}$$

$$\text{Charge/discharge time (in hours)} = \frac{\text{Amp-hour rating}}{\text{Continuous current (in Amps)}}$$

IV. Conclusion

The ESs is generally required low current, but designed PS is useful for low and high current applications. The capacity of the battery is 12V/4.5Ah, it means the battery can supply 4.5Ampere current up to 1 hour. If ES needs 100mA current, than the battery can supply 12V up to 45 hours, it means the designed PS can supply 5V and 100mA up to 45 hours during off line condition.

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