

proceedings of the tenth international conference on

CHALLENGES in HIGHER EDUCATION and RESEARCH in the 21st CENTURY

organized by the Technical University of Sofia
June 5-8, 2012, Sozopol, Bulgaria

edited by.

Tasho Tashev, Radoslav Deliyiski, Badea Lepadatescu



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Vol. 10

Edited by Tasho Tashev, Radoslav Deliyiski, Badea Lepadatescu

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PREFACE

The tenth Jubilee international conference “Challenges in Higher Education and Research in the 21st Century” (CHER21-12) organized by the English Language Faculty of Engineering (ELFE) of Technical University of Sofia was held on June 5-8, 2012.

Initiated a decade ago by prof. Nikolay Kolev the conference had its ups and downs through the years, before recognized as a reputable event across the world. Presentation of recent scientific and pedagogical research of faculty members, partner organizations and colleagues involved in teaching at ELFE as well as guests was turned into tradition. The organizers and participants efforts resulted to better organization and higher level of presented reports and made sure the bright conference future. The tenth conference got together participants from Bulgaria, Romania, Austria, USA, Spain and Colombia. The research areas they covered are as follow:

- Education through and for Excellence in Research
- Higher Engineering Education
- Measurement and Control
- Information Technologies and e-Management
- Computer Aided Engineering
- Design and Manufacturing
- Business and Marketing
- Humanities Role

This 10th volume of the series, includes 62 papers of the talks presented at the Jubilee conference of English Language Faculty of Engineering.

The editors of this volume would like to thank to all conference speakers and authors in this volume for their contributions.

Editors: Tasho Tashev, Radoslav Deliyiski, Badea Lepadatescu

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OVER VOLTAGE AND OVER CURRENT PROTECTION FOR ELECTRONIC DEVICES

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Abstract: Different types of electronic devices are widely used everywhere in the modern life. Transient and dc voltages or currents higher than maximum allowable values can lead to failure of the equipments. Over voltage and over current protection circuits are necessary to be used in order to prevent the expensive control and measurement electronic systems from damaging. In this paper are presented received investigation results of over voltage and over current protection circuits appropriate for various applications. The temperature characteristics of trip voltage versus temperature are evaluated.

Keywords: over voltage protection, over current protection.

1. Introduction

Today different electronic devices are used in many different applications. Any transient or dc voltages higher than maximum allowable values can seriously destroy the control or measurement systems. Sometimes these events can lead to loss of very expensive equipments. Any damage may cause inaccurate information obtained by special measurement systems. The over voltage protection circuits are needed to prevent electronic devices from damaging. Those circuits have to protect the equipments not only from unusually high voltages, but also from eventual high currents and possible spark.

This paper presents the investigations results of over voltage and over current protection circuits appropriate for different applications. Some general information about these equipments is given in Section 2. The basic details of surge protection devices (SPDs) such as metal-oxide varistors (MOVs), gas discharge tubes (GDT) and silicon avalanche diodes (SAD) are given. Simulation results of an over voltage protection circuit which disconnect the load when input voltages are higher than 30 V are presented in Section. Such types of electronic devices exist in automotive applications. All of the simulations are made with Cadence OrCAD PSpice.

2. Over Voltage and Over Current Protection Circuits

One of the main features of over voltage and over current protection circuits is to disconnect the protected electronic devices from the eventual sources of high transient or dc voltages or high currents. They don't have to degrade the overall performance of the control and measurement systems. The requirements which have to be performed from transient suppression devices are that they have to limit the voltage; limit the current; divert the current; operate fast; be capable of handling the energy; survive the transient; have a negligible affect on the system operation; fail safe; have a minimal cost and size [1].

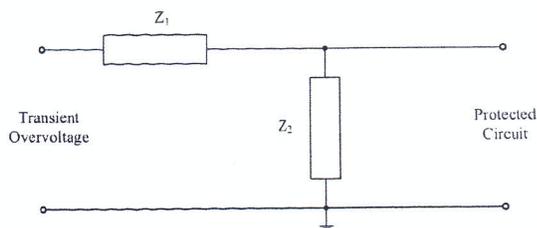


Figure 1. Transient voltage protection circuit.

In some applications when very high voltages and currents have to be limited surge protection devices are used. Such type protection components are metal-oxide varistors (MOVs), gas discharge tubes (GDT) and silicon avalanche diodes (SAD). When transient or dc voltages with higher than maximum allowable values appear at the input, those electronic devices shunt the input to the ground. They have large impedance during the normal operation of protected circuit and small impedance when voltage exceeds there threshold levels. The clamping voltage should be smaller than maximum allowable for the protected electronic circuits.

Principal of operation could be explained with the equivalent circuit shown in Figure 1 [2]. The series element Z_1 has to limit the current which is flowing through the shunt when high transient or dc voltage is appearing at the input. The value of this component should be precisely chosen, because on the other hand drop voltage over Z_1 doesn't have to be large.

Transient over voltages or surges can appear at the input due to the release of large amount of energy stored in the inductance and capacitance components of the systems [3]. The sources could be lighting, electrostatic discharge, alternators in the automotive applications etc.

Surge protection devices can limit very high levels of transient or dc voltages and currents. These devices clamp the input voltage to levels smaller than maximum allowable of the protected electronic circuits. Some basic information about metal-oxide varistors (MOVs), gas discharge tubes

(GDT) and Silicon avalanche diodes (SAD) is given in this section.

Metal-oxide varistors are nonlinear variable resistors which can maintain low clamping voltage. They can be used for positive and negative voltages. These components can withstand the current of hundreds or thousands of amperes range.

The gas discharge tubes (GDT) have high or small value of impedance, respectively when input voltage is smaller or bigger than threshold of the GDT. The voltage across the GDT is clamping to the threshold level [4]. Gas discharge tubes can withstand the current of tens thousand of amperes. The response time of these devices is bigger compare to metal-oxide varistors. The spark developed between the electrodes of GDT is dangerous to the electronic systems which are nearby them.

Silicon avalanche diodes are similar to the zener diodes, but they have larger p-n junction area. Silicon avalanche diodes (SAD) clamp the transient overvoltage at a low residual value [3]. These devices have to divert the transient current away from the protected circuit. They are faster compare to metal-oxide varistors and gas discharge tubes. Silicon avalanche diodes respond rapidly to the transient voltage surge. Their disadvantage is that they cannot absorb large input energy. Therefore in some applications several SAD are combined together.

Surge protection devices are used in the applications when large amount of energy has to be absorbed.

3. Investigation Results

Investigation results of different over voltage protection circuits are presented in this section. The simulations are made with Cadence OrCAD PSpice.

These are, for example electronic equipment in some automotive applications which can work properly when the input voltages are maximum 30 V. At voltages higher than these levels such electronic devices can be destroyed. Therefore they should be protected from transient or dc voltages higher than 30 V. Over voltage protection circuit is needed in order to save these electronic systems.

A potential source of voltages higher than 30 V in the automotive applications is for example alternator. In some cases the voltage could reach level as high as 80 V. The over voltage protection circuit should ensure safe operation of electronic equipments. Input voltage should be disconnecting from the load when its level is higher than 30 V.

The block diagram of investigated over voltage protection circuit is shown in Figure 2.

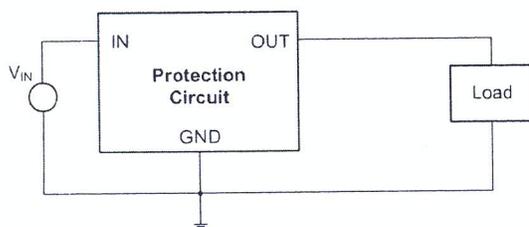


Figure 2. Block diagram of over voltage protection circuit.

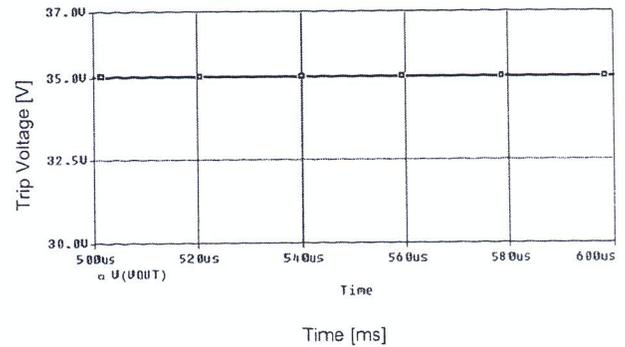


Figure 3. Simulated trip voltage of circuit from Figure 2 when input voltage is equal to 80 V.

Simulated result for trip voltage of circuit from Figure 2 is presented in Figure 3.

The input voltage V_{in} is equal to 80 V. As can be seen from Figure 3 trip voltage is approximately 35 V. The investigations show that over voltage protection system reacts when input voltage 16% higher than 30 V. This result is achieved when the temperature is 27°C.

Investigation results of trip voltage at different temperatures are shown in Figure 4.

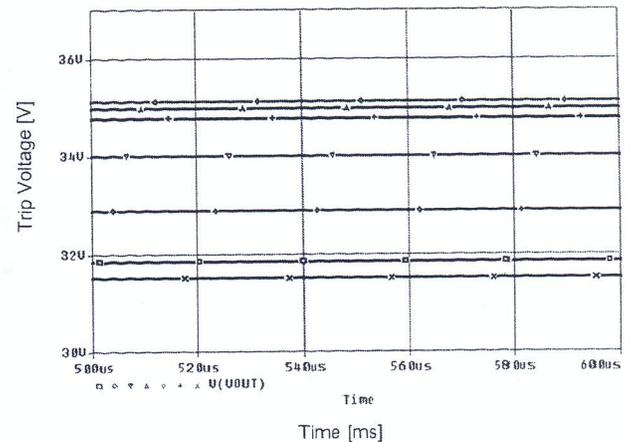


Figure 4. Trip voltage of circuit from Figure 2 when input voltage is equal to 80 V at different temperatures.

Detailed results are presented in Table 1. Temperature changes from -50°C to 70°C. At this range trip voltage of the investigated over voltage protection circuit is changed from 31.5 V to 35.1 V.

Table 1. Trip voltage of circuit from Figure 2 when input voltage is equal to 80 V at different temperatures

Temperature, [°C]	-50	-25	0	25	40	50	70
V_{out} , [V]	31.5	31.8	32.8	34	34.7	34.98	35.1

Temperature characteristics of trip voltage of investigated circuits are presented in Fig. 5.

Temperature coefficient of trip voltage is evaluated. Simulation results show that when load is protected from input voltages higher than 30 V its value is 30 mV/°C.

The investigated circuit could protect electronic devices from transient or dc voltages higher than 30 V. Tempera-

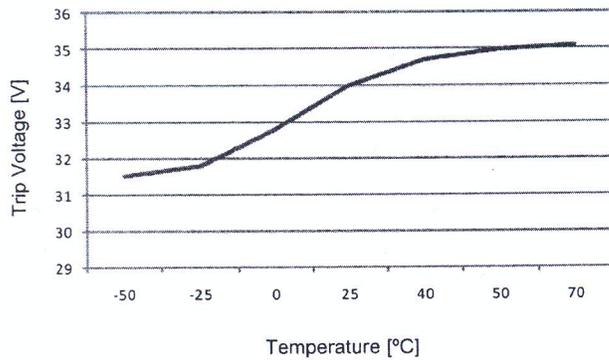


Figure 5. Trip voltage versus temperature for circuit from Figure 2 when load is protected from input voltages higher than 30 V.

ture investigations show that over voltage protection circuit can ensure safety operation of equipment in wide range.

4. Conclusion

Over voltage and over current protection circuit is needed to protect electronic devices from unusual high transient and dc levels. Thus safety operation without damaging of the equipment is ensured. Investigation results of over voltage protection circuits appropriate for different applications are presented. The temperature characteristics of trip voltages

are evaluated. Cadence OrCAD PSpice is used for simulations. The achieved results for analyzed circuits show that when load is protected from input transient or dc voltages higher than 30 V temperature coefficient of the trip voltage is 30 mV/°C. Investigations show that over voltage protection circuit can ensure safety operation of protected electronic devices in wide temperature range.

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