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EMP EFFECTS STUDY OF M151 VEHICLE SOLID-STATE ELECTRONIC COMPONENTS

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HEADQUARTERS
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ABSTRACT

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The subject of this report is a study of the electro-magnetic pluse (EMP) vulnerability of M151 vehicle 25-ampere regulators and 60-ampere generating systems containing solid-state electronic components. The intent is to determine the susceptibility of the M151 and other vehicles employing the same components to damage in the presence of EMP fields which accompany the detonation of nuclear weapons. The test was conducted at the Mobility Research and Development Center's biconic antenna EMP facility located at Fort Belvoir, Virginia. The results of these tests indicated that the 25-ampere, 28-volt DC solid-state regulator and the 60-ampere, 28-volt DC generating system will operate satisfactorily in EMP fields of 70-kilovolts/meter.

FOREWORD

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The electromagnetic study herein reported was conducted by the Physical Sciences Laboratory of the U. S. Army Tank-Automotive Command. The test was performed at the biconic antenna EMP facility of the U. S. Army Mobility Equipment Research & Development Center, Fort Belvoir, Virginia.

Authorization for this evaluation was provided by AMC Management Structure Code 2270.1, "Production Engineering for PEMA Items".

The authors wish to thank Mr. James G. Brookes for many helpful discussions concerning the test. We wish to acknowledge MERDC, James Foutch (USATACOM), and Bill Bracey (USATACOM), for their help in conducting the test.

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INTRODUCTION

The detonation of a nuclear weapon creates radiation and electromagnetic phenomena from the nuclear interaction of the fission and fusion processes. These phenomena will have varying degrees of detrimental effects on materiel exposed to them, depending on the phenomena and the nature of the item. The specific phenomena studies in this test is that of the electromagnetic pulse. This pulse extends outward to great distances for its source. Normally the intensity of electromagnetic waves varies inversely with the square of the distance from the source, but the pulse created by a nuclear weapon drops off much more slowly with distance.

Most Army materiel is designed to survive the conditions that exist on the conventional battlefield with only moderate consideration given to the problem of survival on the nuclear battlefield. The emphasis placed on evaluating the effects of nuclear environments is increasing and requirements are being made upon vehicles and systems to survive and operate in a nuclear weapons environment. The Electromagnetic Effects Laboratory of the Mobility Equipment Research and Development Center at Fort Belvoir, Virginia has recently performed a study of the vulnerability of some Army systems to the electromagnetic pulse found in a nuclear environment.

This report will be concerned with the study of the effects of an electromagnetic pulse on solid-state electronic components. Our specific concern will be with a 25-ampere regulator and a 60-ampere generating system mounted in an M151 vehicle.

OBJECTIVE

Analyze USATACOM developed components containing solid-state electronic systems for performance capability when subjected to the EMP environment resulting from a nuclear detonation, thereby ensuring continued operation of vehicles employing these components.

METHOD AND PROCEDURE

The test was conducted at the AP Hill Military Reservation near Fredericksburg, Virginia. The biconic antenna EMP facility was operated by personnel from the Electromagnetic Effects Laboratory from Fort Belvoir, Virginia. An M151 was used on a test vehicle. The solid-state components were mounted on the vehicle and subjected to an electromagnetic pulse. The regulators were checked for proper voltage regulation before, during and after the pulse. Measurements were made of the potential drop across the battery and the current flow.

During the test of the 25-ampere regulator, voltage and current measurements were made at locations indicated in Figure 1. Measurements were made as indicated in Figure 2 for test of the 60-ampere systems. These voltages and current measurements were made with the vehicle aligned parallel with and perpendicular to the direction of propogation of the electromagnetic pulse. They were also made with the hood up and the hood down to vary the effective electrostatic shielding of the regulator.

Three 25-ampere regulators (manufactured by Varco Inc.) were tested. Three 60-ampere generating systems were also tested: one build by Prestolite, one by Ford, and one by Leece Neville. The 25-ampere regulators each contained 1 SCR, 8 transistors, and 6 diodes. The 60-ampere systems typically contained 3 zener diodes, 4 diodes, and 2 SCR's.

Each regulator was mounted in the vehicle and the vehicle was then driven to the test position. Pulses were triggered no faster than one every two minutes. The peak pulse amplitudes were typically 70 kilovolts/meter. Engine speed during the tests was a fast idle. A particular regulator was normally subjected to a total of nine pulses over a period of about hald an hour to an hour. Comparisons were made ot the performance of the regulators with regulators that had not been subjected to an electromagnetic pulse.

RESULTS AND DISCUSSION

Typical results obtained for the 25-ampere regulators are depicted in the raw data shown in Table I. Data shown pertains to one regulator only since test results on all three 25-ampere regulators were similar. One can easily see there was no measurable change in the voltage regulation during the pulse or any time thereafter. This test was conducted on a 25-ampere, 28-volt DC regulator, Military Part Number 11631857, Federal Stock Number 29208007218. The regulator showed no ill effects of the pluses even with loads as high as 25.5 amperes.

Corresponding results for the 60-ampere systems are shown in Table II. Test results shown are for one 60-amperes system only omitting the remaining two systems as the test results are similar. Here again one can see that, even with loads as high as 54, there was no noticeable change in the voltage regulation. This table depicts results of a test conducted on a 60-ampere, 28-volt DC Generating System, Federal Stock Number 2920-909-2483, Military Specification G-46795. The hood position had no effect on either system.

All regulators and generating systems were bench-tested in the laboratory after the test and found to operate identically to other regulators that had not undergone the test.

CONCLUSIONS

The results of these tests indicate that the 25-ampere, 28-volt DC solid state regulator and the 60-ampere, 28-volt DC generating system will operate satisfactorily in EMP fields of 70 kilovolts/meter. Product modification to ensure continued operation of these units in the presence of electromagnetic effects will not be required.

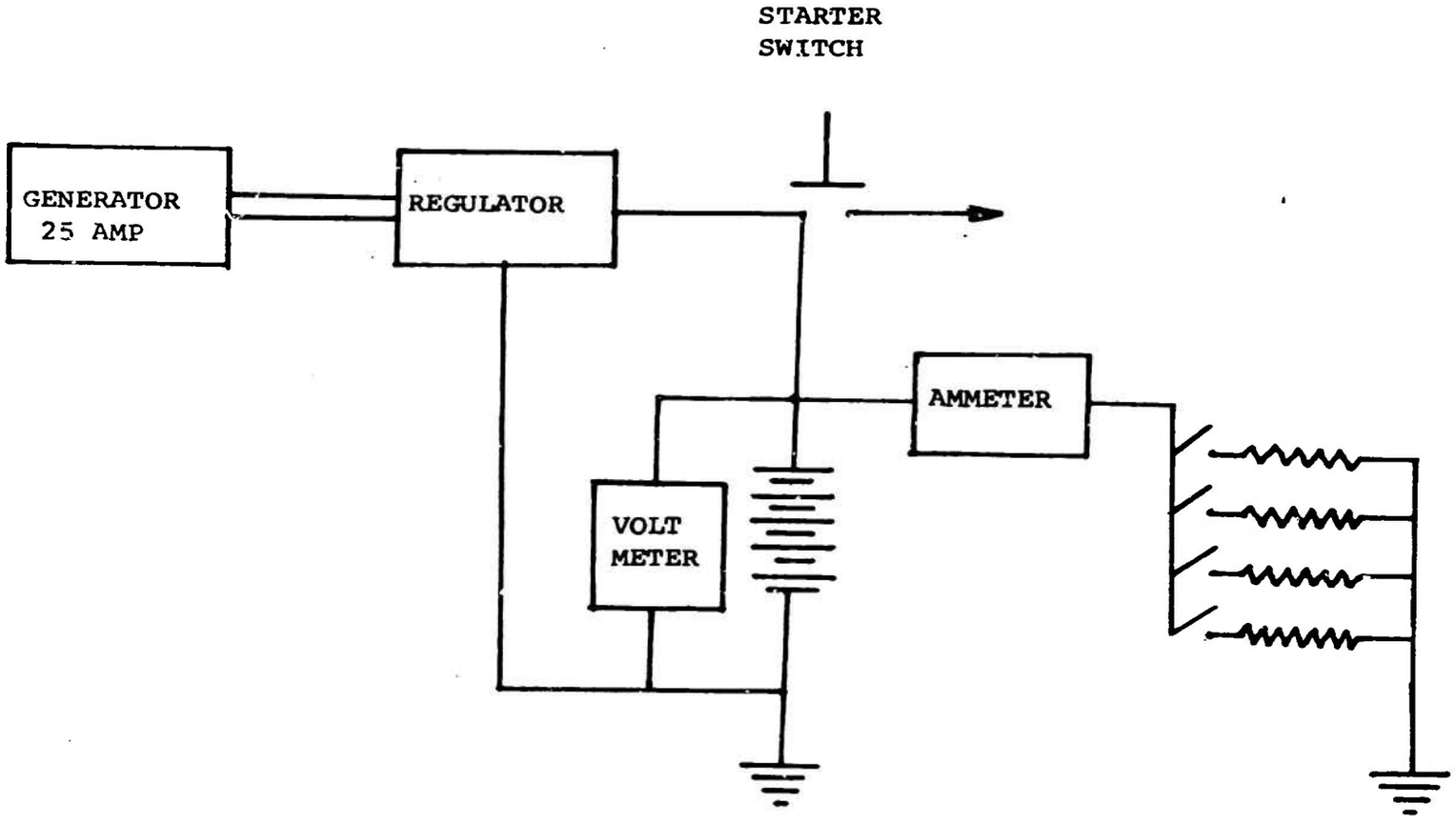


FIGURE 1 - LOAD CIRCUIT FOR 25 AMPERE VOLTAGE REGULATOR TEST

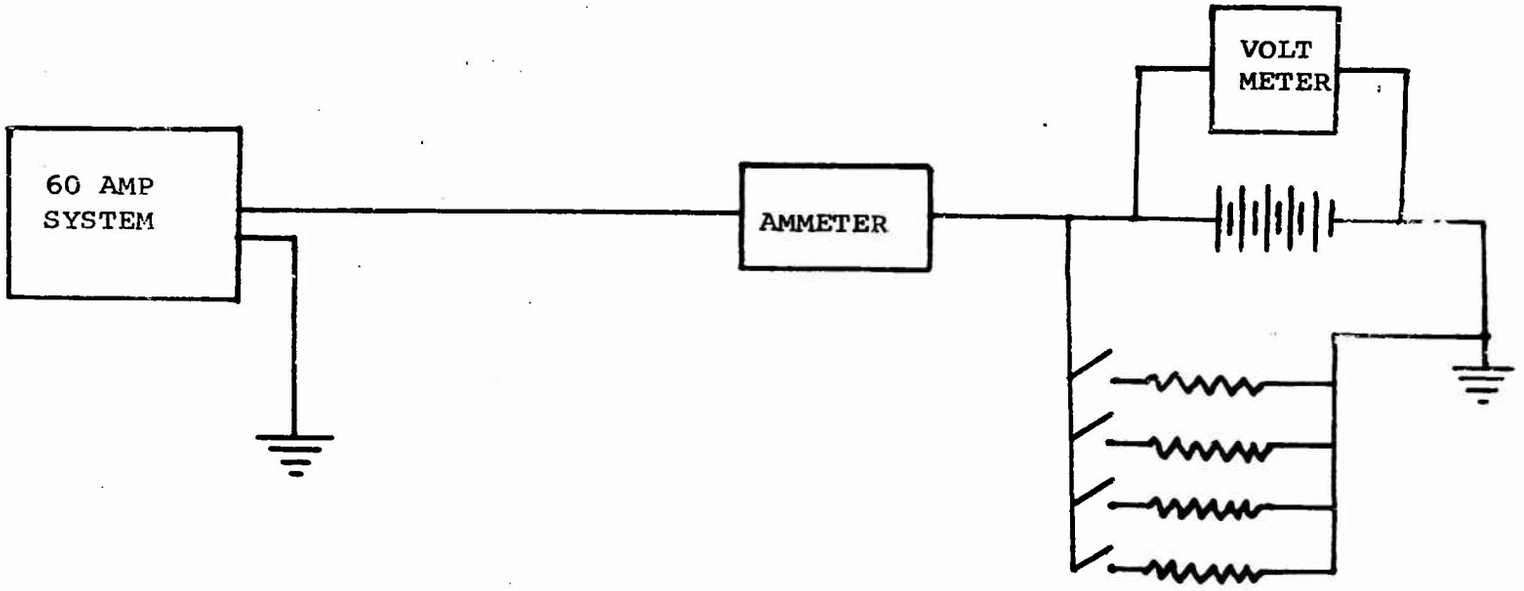


FIGURE 2 - LOAD CIRCUIT FOR 60 AMPERE GENERATING SYSTEM TEST

TABLE I

TYPICAL RESULTS - 25-AMPERE REGULATOR EMP EFFECTS TEST

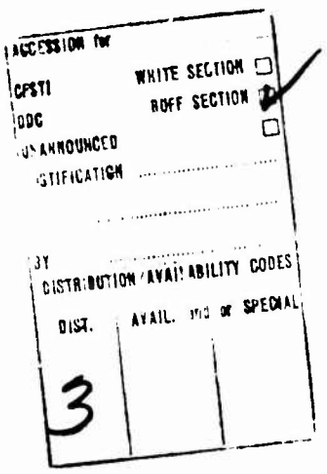
EMP PULSE NO.	VOLTMETER READING (VOLTS) BEFORE PULSE	VOLTMETER READING (VOLTS) DURING PULSE	AMMETER READING (AMPERES)	VEHICLE POSITION	HOOD POSITION
1	28.0	28.0	0	Parallel	Down
2	28.0	28.0	0	Parallel	Up
3	28.0	28.0	0	Parallel	Up
4	27.0	27.0	18.5	Parallel	Down
5	27.0	27.0	18.5	Parallel	Down
6	26.9	26.9	18.5	Perpendicular	Up
7	25.5	25.5	25.5	Perpendicular	Up
8	25.5	25.5	25.5	Perpendicular	Up
9	25.5	25.5	25.5	Perpendicular	Up

TABLE II

TYPICAL RESULTS - 60-AMPERE GENERATING SYSTEM EMP EFFECTS TEST

EMP PULSE NO.	VOLTMETER READING (VOLTS) BEFORE PULSE	VOLTMETER READING (VOLTS) DURING PULSE	AMMETER READING (AMPERES)	VEHICLE POSITION	HOOD POSITION
1	28.5	28.5	8.0	Parallel	Down
2	28.5	28.5	8.0	Parallel	Down
3	28.5	28.5	7.5	Parallel	Down
4	28.5	28.5	54.0	Parallel	Down
5	28.5	28.5	54.0	Parallel	Down
6	28.5	28.5	54.0	Parallel	Down
7	28.5	28.5	54.0	Perpendicular	Down
8	28.5	28.5	53.5	Perpendicular	Up
9	28.5	28.5	54.0	Perpendicular	Up

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.



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