IEMI Microcontroller Effects

An Overview of Recent Results

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Abstract — Using a state-of-the-art automated testing system called SALVO, pulsed RF signals were direct-injected into the clock line pin of a microcontroller (MCU) using careful timing. The MCU is programmed in assembly language to execute a simple binary counter, and we monitor the output of this counter to establish whether an upset has occurred. Since the timing of the MCU program is well understood, an RF pulse can be injected at specific instructions and locations relative to the rise and fall of the clock signal. An experiment to understand how the probability of effect (PoE) changes as a RF pulse is injected at different locations relative to the rising and falling clock signal was performed. The rising edge clock state showed the highest PoE while the, clock low state showed the lowest PoE. Additional experiments were performed as follow-on to this effort, please see reference paper for additional experiments and results. [1]

Keywords - IEMI, Microcontroller, MCU, HPM, Effects, Automated experimentation.

I. INTRODUCTION

In the area of electromagnetic effects on electronics the most challenging technical problem is to understand and model the process of upset for digital systems. We have studied microcontrollers for their relative simplicity and ease of programming and control as a model for more complex system behavior.

II. SALVO & EXPERIMENTAL SETUP

SALVO is an automated testing apparatus that controls the lab equipment - that creates and injects the RF pulses - based on a user defined experiment set up file. The user specifies the parameters of the test desired, then SALVO executes the experiment, processes the data and finally exports a summary of the results. An image of SALVO and the MCU test-board can be found in Fig.1.

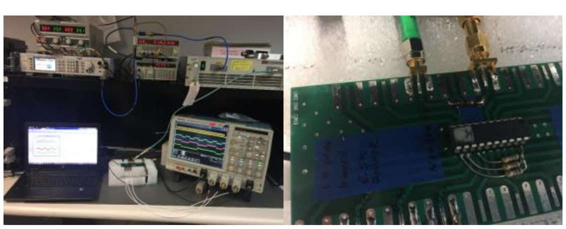

Figure 1. SALVO Test Apparatus (left), MCU test-board (right)

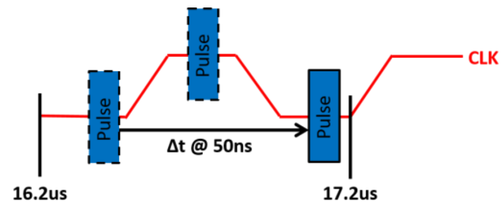

Figure 2. RF pulse injection cartoon on MCU clock signal.

III. EXPERIMENT

The MCU was programmed to count from 0 to 7, then repeat. The experiment focused on the time window encompassing the first clock cycle of the ADD operation – A 50ns pulse was injected at 16.2us, then shifted by 50 ns steps to 17.2us - See Fig. 2 for an example cartoon. This allowed the single pulse to ride along the low, rising, high, falling, and low states of the clock signal. Four different power levels were tested: -15db, -14db, -12db, and -10db, relative to a 20W peak solid state RF amplifier.

IV. RESULTS

Fig.3 suggests that the most sensitive locations for upset were the rising and falling edges of the clock - 16.4us and 16.9us - as the PoE was almost always 100%. Injection times between 16.4us & 16.9us showed significant variation as a function of power suggesting a hardware/transistor level response to the pulsed RF. Higher power signals - -10db - produced high PoE between 16.4 & 16.9us but did not affect the clock low regions at all – 16.2 to 16.3 and 17.0 to 17.2us.

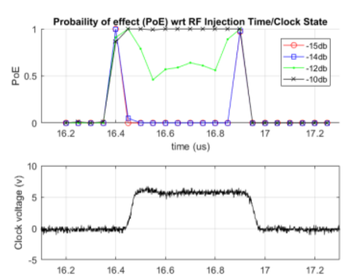

Figure 3. PoE as a function of power and injection location

REFERENCES
[1] D. Guillette, T. Clarke, "An Overview of Recent Microcontroller Upset Task Efforts," AFRL Technical Memo, March 2018.