Experimental and Theoretical Analysis of RF and Digital Systems in Presence of Complex Platforms Subject to Electromagnetic Interference

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We present an experimental and theoretical evaluation of digital modulation schemes subject to EMI through RF Power Amplifier and a digital Timer inside an Automobile. For the digital modulation schemes, we consider various modulation schemes to evaluate performance (Error Vector Magnitude, Upset or Failure) subject to in-band and out-of-band EMI. For the digital timer, we consider Gaussian pulses with varying pulse width and length impinging upon the device inside an automobile. To observe device level EMI effects, a detailed EMI analysis is performed for the RF-Power Amplifier and the digital timer with emphasis on non-linear effects due to high power EMI illuminations. Measurements and simulations are carried out to observe EMI effects on both system and device level.

The performance of digital modulation schemes such as the Quadrature Phase Shift Keying (QPSK), Quadrature Amplitude Modulation (QAM) and binary modulation schemes such as Binary Phase Shift Keying (BPSK) are evaluated by computing the Error Vector Magnitude (EVM). Both in-band and out-of-band frequencies are injected into the system to study the vulnerability of the modulation schemes on intentional EMI. We are able to associate the overall effects with either direct deterioration of the modulated signals or an overall upset on the electronic modules that process the modulated signals. To do so, an RF-power amplifier is employed prior to the transmission stage and examined device effects on the modulated signal by measuring the EVM.

We also examine a timer designed via MOSIS technology to study EMI effects on the performance of the digital chip. We illuminate the timer inside an automobile illuminated with Gaussian pulses and studied the effects on the chip with varying pulse widths and periods. In addition to the timer, we also expose the power amplifier inside a metallic enclosure to high power plane wave illumination as a more practical setting. For both complex problems, our analysis incorporates a hybrid S-parameter matrix for system modeling of the entire structure. Specifically, we integrate full wave EM models of the structure with a Harmonic Balance Circuit analysis to model the PCBs and RF (as well as digital) devices. Such analysis is very general and allows for complete realistic evaluation of performance deterioration associated with active RF devices in realistic settings.