Vulnerability Study of RS-232 Interfaces Caused by Electromagnetic Interferences with Repetition Rate

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Abstract—The serial digital communication systems are vulnerable to electromagnetic interferences, especially which have high power and wide band. For what might happen to systems exposed by such kinds of threats, characteristics of both the victims and interferences play great parts. This paper focuses on how the electromagnetic interferences with repetition rate affect the RS-232 interfaces and tries to figure out how the baud rate affects the result quantitatively. Relevant results have been verified with experiments in laboratory.

Keywords- Electromagnetic Interference; Repetition Rate; Effect Experiment; RS-232 Interface

I. INTRODUCTION

As a typical representative of serial digital communication, the RS-232 interface is widely used in wire communication with short distance, low speed and little price. Because signals are almost directly transmitted without any modulation, consisting of many DC and low-frequency components, they are very vulnerable to high-power electromagnetic interferences. When interfered, the digital signals might be recognized mistakenly to their opposite meanings (i.e. '0' to '1' or vice versa). This commonly called 'bit errors' can result in great influences while communicating even though every single part of the systems actually has less vulnerability to the interferences. There are also needs to figure out which characteristics affect the result and how they make these happen.

II. THEORETICAL ANALYSIS

For RS-232 standard doesn't have a synchronous clock, both the transmitter and receiver must make sure the transmission speed the same one before starting the communication. Assume that the transmitter tries to send a digital sequence defined as $\{x_n\}$ with the transmission speed (baud rate) R in bps on a signal channel with its impulse response $h(t)$. Just on the same channel, by either coupling or injecting, the electromagnetic interference $u_{pulses}(t)$ with repetition rate of f_{PRR} exists, resulting in an overlap of both signals and interferences. The new 'signal' on the channel is then sampled as $\{r_k\}$ by the receiver with the same baud rate R, which is

$$r_k = x_k h(t_0) + u_{pulse}\left(t_0 + \frac{k}{R} - \frac{i_k}{f_{PRR}}\right), \qquad (1)$$

where t_0 is a constant number to adjust the time lag between the signal sampling and pulse occurrence.

Usually $u_{pulse}(t) \gg x_k h(t)$, so only when the interfered signals exceed the threshold level d, the bit errors happen. Because t_0 can value any value as there is totally no timing relationship between the signal and pulse, the u_{pulse} can value among its domain of values with uniform probability. As a consequence, the bit error rate (BER) relies on the probability distribution of u_{pulse}, therefore

$$P_e = \int_d^{\infty} f_{u_{pulse}}(u)\mathrm{d}u + \int_{-\infty}^{-d} f_{u_{pulse}}(u)\mathrm{d}u, \qquad (2)$$

where $f_{u_{pulse}}(u)$ is the probability density function of u_{pulse}.

As which way it is defined, $f_{u_{pulse}}(u) \propto R$, what is to say the BER is directly proportional to baud rate if under the same pulse interference.

III. EXPERIMENTAL VERIFICATION

An experiment has been conducted to verify the proposed inference. A pulse generator with 100 Hz repetition rate was involved in the test. Then a normal RS-232 transmission system was interfered by currents induced on the channel due to the pulse generated nearby. Only baud rate was changed purposely from 4800 to 172800 bps. The experiment setup was shown and the BER curve was drawn under baud rate with a linear regression in Figure 1.

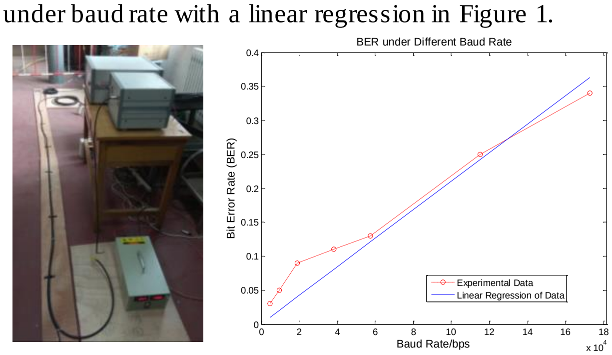

Figure 1. Experiment setup (Left) and BER under different baud rate (Right)

It can be seen that the BER curve is likely a straight line as the model above described, though there exists some flaws at low baud-rate regions, which might come from the error when estimating occurrence of small probability case.

REFERENCES

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