RECEIVING CHARACTERISICS OF THE ELECTROMAGNETIC INTERFERENCE ON DC POWER SUPPLY LINE WITH INVERTER GATE LOAD

Atsushi Yoshida, Takehiro Takahashi, Takashi Sakusabe, Noboru Shibuya, Atsuo Mutoh* and Shuichi Nitta**

Takushoku University, Tokyo Fuji University* and Salesian Polytechnic**

E-mail: ayoshida@cs.takushoku-u.ac.jp

Abstract: The crosstalk on the power-ground line victim circuit consisting of the digital Inverter IC circuit was measured. The crosstalk depends on the dynamical states of the victim circuit. The obtained crosstalk waveform is the sum of the voltage variation of the IC power line at High/Low state and the intrinsic crosstalk. Furthermore it is understood that the power line voltage variation is caused by the thru current through the output gate of IC in case that the state of the inverter IC changes from High/Low to Low/High state around the input transient region. The waveform of the voltage variation changes depending on the change of the internal state of the inverter IC.

Key words: receiving characteristics of circuit, immunity of the equipment, crosstalk, the input transient region of IC

1. Introduction

In this study the receiving characteristics of the EM interference are investigated on the circuit whose characteristics changes in time domain.

When the EM field is controlled below the limited value, the field strength is measured using standard dipole or similar antenna. This field strength, however, may be different from the value which the exposed electronic equipment (EUT) receives in the controlled area, because the receiving characteristics of the equipment is different from the standard antenna. Especially the receiving characteristics of the electronic equipment may be changed by its time-dependent condition. This leads to the change of the receiving characteristics. These characteristics are measured and investigated relating with the immunity characteristics of the equipment in this study.[1-3]

As the first step, the receiving characteristics of EM interference are studied experimentally. The crosstalk form the generator circuit is used as the EM interference field and an induced voltage on the victim circuit is measured in order to investigate the receiving characteristics of the victim circuit. The victim circuit simply consists of the digital inverter IC circuit and EM field was induced to power ground line of the circuit. And the induced crosstalk was measured.

2. Experimental set-up

For measurement of the receiving characteristics of electromagnetic interference on DC power supply line with inverter IC, the following circuit was equipped.

The experimental circuit is shown in Fig.1. The circuit is so constructed that the electromagnetic interference is given from the inner driver circuit to the outer victim circuit. The driver circuit, which generates EM interference consists of a signal generator and signal-ground line with resistive load R1. The victim circuit consists of the Inverter IC, the load circuit with capacitor C1 and resistor R2, and a power supply or a function generator for input of the IC.

The power supply and ground lines of the victim circuit are separated 20 cm and extended enough to couple with generator circuit. The lines are tightly twisted with the signal and ground lines of the driver circuit in order to make strong coupling. The inverter IC is supplied by 5V.

In this measurement, the voltage waveform of the driver circuit was measured at the point a, and voltage waveform of the victim circuit was measured at the point b of Fig.1.

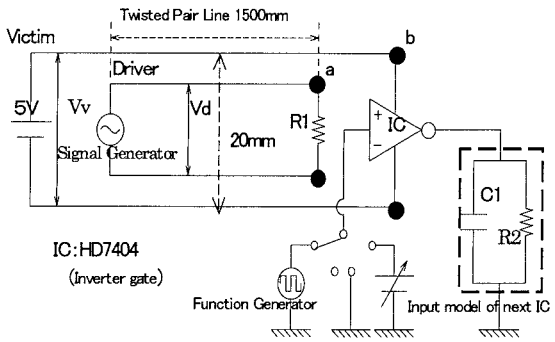


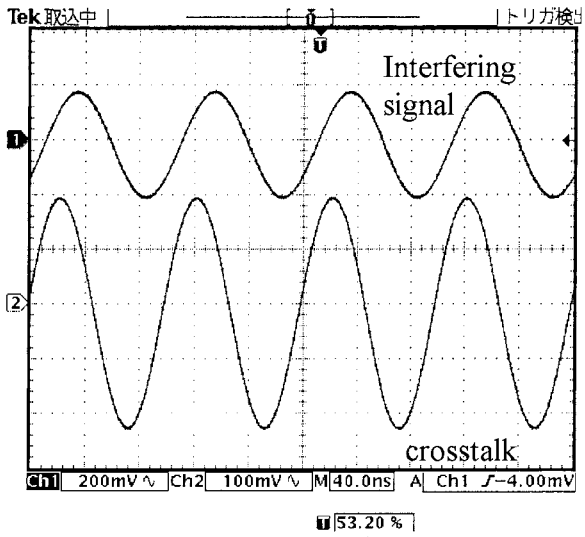
Fig.1 Measurement circuit

3. Measurement results

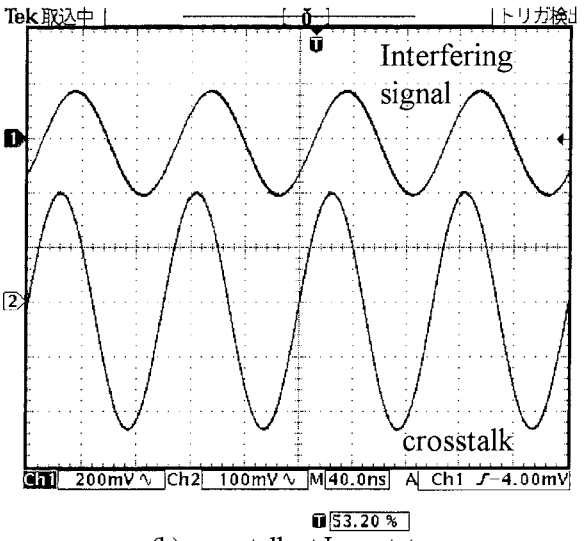
3.1 Receiving characteristics at the static IC state

The receiving characteristics at the static IC state are measured by using the circuit shown in Fig.1. The state of IC is either High level (5V) or Low level (0V). The driver circuit is activated by the 10MHz sinusoidal wave. The voltage waveform at the point b in Fig.1, thus the voltage at the victim circuit, is shown in Fig.2 (a) (High state) and Fig.2 (b) (Low state) respectively.

The center voltage of these waveforms in the figure is DC 5V power supply voltage. These signals are coupled one with the crosstalk and the frequency is 10MHz. As the result, the voltage at victim circuit is the derivative of the driver circuit voltage.



(a) crosstalk at High state



(b) crosstalk at Low state

Fig.2 Voltage waveform of the crosstalk at the static state

In this case, induced voltages are almost 420 mV p-p in High or Low state of IC. For comparison, the voltage waveform is shown in Fig.3 when the IC is replaced by 50 Ω resistor as a load of victim power line. This waveform is also 10 MHz crosstalk, but about 150 mV p-p. The induced voltage on power supply line depends on the load impedance of the power-ground line. If the impedance between power and ground terminal of IC was changed by its state, the induced voltage may be also changed. This change may lead the receiving characteristics of victim circuit.

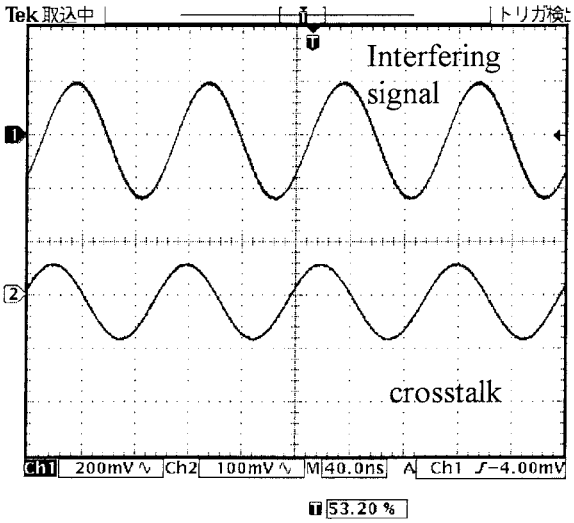


Fig.3 Voltage waveform when IC is replaced with 50 Ω load

3.2 Receiving characteristics at the input transient region

The IC is left in unstable condition when the IC input is fixed near the threshold level. In this case, the power-ground impedance of the IC may be different from that of stable condition. Then the crosstalk of the victim circuit was measured in this condition.

The input/output characteristic of the inverter IC was first measured to clarify the input transient state of IC. Fig.4 shows the measured input/output characteristics. As shown in Fig.4 there exists the input transient state (circle) at which the voltage change rate is discontinuous around the threshold voltage level from input High to Low state.

The receiving characteristics at the input transient region are measured on the circuit shown in Fig.1.

The input voltage of inverter gate is set to the certain value, for example 1.36V or 1.41V, which is called as "input transient region" in this paper. The 100MHz sinusoidal wave is given to the driver circuit. The voltage waveform for the IC input voltage 1.41V at point b of Fig.1 is shown in Fig.5. From this measurement the input transient region was obtained as the voltage between 1.32V to 1.42V.

The complex waveform of the value c.a.700mV are observed and these waveforms are different each other by the input voltage and it is furthermore difficult to have same waveform.

Therefore, it is confirmed that the 10MHz sinusoidal wave, which is the crosstalk noise from the driver circuit is overlapped for the fluctuation generated on the power supply voltage of inverter IC.

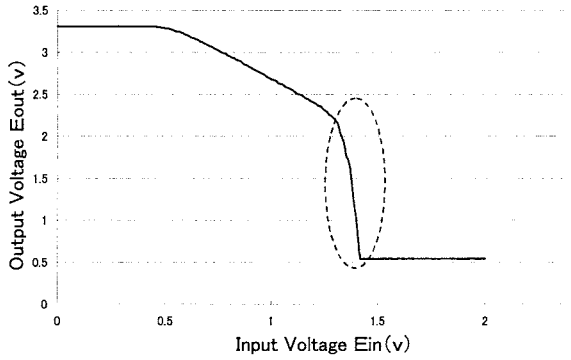


Fig.4 Input/output characteristic of inverter IC

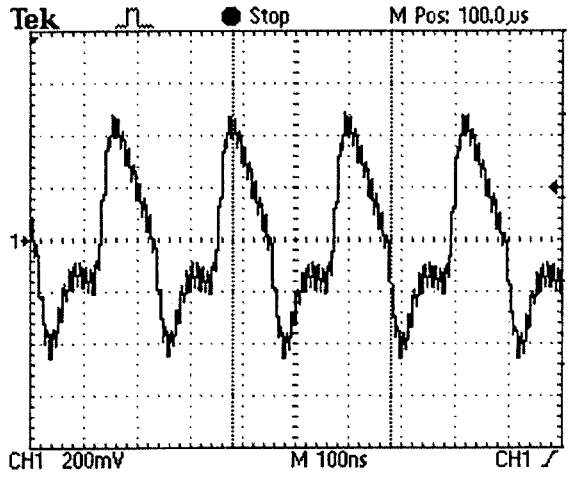


Fig.5 Voltage waveform on the victim (Input voltage 1.41V)

3. 3 Receiving characteristics at the dynamic IC state

The receiving characteristics at the dynamic IC state are also measured by using the circuit shown in Fig.1. The 100 kHz sinusoidal wave signal is input to the Inverter IC by the function generator. The 100 MHz signal is given as the interference signal from the driver circuit in Fig.1. The voltage obtained at the point b of Fig.1 is shown in Fig.6, and the frequency spectrum of it is shown in Fig.7.

As shown in Fig.6 the 100 kHz voltage variation, the frequency of which is the same as the input pulse of IC inverter, is observed on the victim circuit voltage wave. The high frequency components are superimposed to the voltage variation. The frequency of this wave corresponds to 100 MHz, which is the crosstalk from the driver circuit.

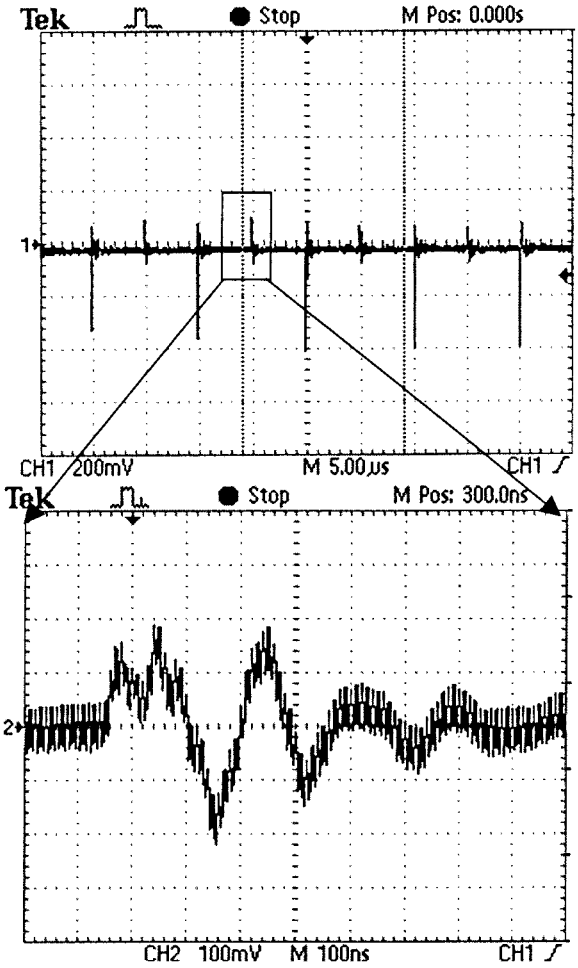


Fig.6 Voltage waveform of the crosstalk on the power line at the dynamic state

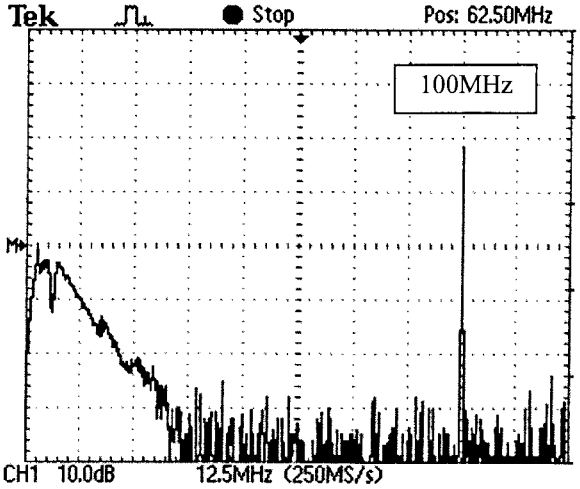


Fig.7 Frequency spectrum of voltage waveform in Fig.6

In the voltage waveform of Fig.6, it is confirmed that the high frequency wave is overlapped to the switching noise of power supply of inverter IC. From the experiments above, in the dynamic operation state of IC, the voltage at the victim are superposition of the crosstalk from the driver circuit and the switching noise of power supply of inverter IC. The receiving characteristics of the noise are different from the case of static state and resistor load.

4. Frequency dependence of receiving characteristics

From the measurements above, it is observed that the induced crosstalk signal from the driver circuit to the victim circuit simply overlaps on the voltage wave of the victim line. The voltage amplitude, however, may be different according to the IC states or the frequency of the induced signal. So the frequency dependence of the crosstalk voltage amplitude in the case of static state of inverter IC was measured. The IC state was fixed in three conditions as 0 V, 1.41 V and 5 V. Fig.8 shows the measured frequency characteristics.

In Fig.8, it was observed that the voltage amplitude of crosstalk was different from that of input state of inverter IC. At the frequency lower than 80 MHz, three lines show different trends, while three lines are almost same at higher frequency. In particular the large crosstalk was observed when the IC was transient condition (input voltage was 1.41 V) in 40-60MHz.

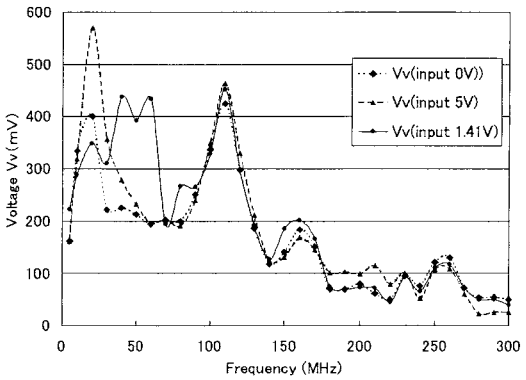


Fig.8 Frequency dependency of voltage amplitude of the crosstalk

5. Conclusion

In this experiment the crosstalk depends on the load characteristics of the victim circuit. The obtained crosstalk waveform is the sum of the variation of the IC voltage power line at static or active state and the crosstalk. In the transient region, large voltage fluctuation was observed on power line and crosstalk was overlapped on it. And in the active state, the power line voltage variation is caused by the thru current through the output gate of IC in case that the state of the inverter IC changes from High/Low to Low/High state around the input transient region. The crosstalk was also overlapped on it. From the measurement of frequency dependence, it is known that the waveform of the voltage variation significantly changes depending on the change of the internal state of the inverter IC and frequency.

References

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