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Study of Electromagnetic Transient on Communication Port and their Solution

[1]Rangnath S Girhe, [2]Dr.P.W.Wani
Department Electronics and Telecommunication,
College of Engineering Pune,
wellesly road shivaji nagar, Pune – 411005,
maharashtra india

Abstract—

In Industry RS485 communication serial port is most prefer port for long distance communication. In field three most appearing transients can disturb or fail the communication of RS485 these transients are Electrostatic Discharge (ESD), electrically Fast Transient (EFT) and Surge.

Out of the three transient surge is the most dangerous transient and it can affect the most because its waveform show that it is for microsecond while other transient is for nano second and once your product can sustain surge transient means it can also sustain other transient also.

Now a day's electromagnetic compatibility (EMC) is measure issue consider while releasing a product and to get CE (European conformity) mark or U/L (underwrites laborites) i.e. safety mark the effect of this transient and their IEC test are compulsory for every manufacturer.

To ensure that port will not get affected by this transient International electro technical Commission (IEC) has recommended immunity requirement standard for ESD, EFT and Surge.

In this paper we have covered information about this transient, standard requirement and their solution.

IndexTerms—**EMC, EMI, EUT, PORT, ESD, EFT.**

INTRODUCTION

RS 485 cable is used for long distance communication due to its differential mode transmission and other properties. In industry this cable may travel through noisy environment and may be affected by transient.

Transient energy can flow into the circuit in two ways first one is conducted and next is radiated. In this paper I have covered transient that flow in the form of conduction and these transient

are ESD,EFT and Surge.IEC standard and protection method used to protect circuit from this transient is also explain.

RS 485

This standard is published by Telecommunication Industry Association and Electronic Industries and Electronic Industries Alliance (TIA/EIA). It is use for long distance communication and electrically noisy environments. It allows multiple devices (up to 32) to communicate half duplex on a single pair of wire plus a ground wire at a distance up to 1200m (4000 feet). [4]

Important characteristic of RS485 are:

Line configuration	Differential
Mode of operation	Simplex or half duplex
Maximum cable length	4000 feet
Maximum data rate	10Mbps
Typical logic level	±1.5V to ±6V

Table 1.Characteristic of RS 485

In real application electromagnetic interference (EMI) transient can damage RS485 so designer should ensure it should work in such environment by following EMC regulation.

ELECTROMAGNETIC COMPATIBILITY (EMC)

Electromagnetic noise can enter in two ways in the circuit and these ways are radiation and conduction. EMC is the ability of the electronic system to function satisfactorily in its intended electromagnetic environment without introducing intolerable electromagnetic disturbances to that environment.

The IEC 61000 standard defined the immunity requirement .All electrical and electronic equipment must satisfy this requirement. This standard has three types of high voltage transient that every electronic system must consider.

- IEC 61000-4-2 ESD Test
- IEC 61000-4-3 EFT Test
- IEC 61000-4-5 SURGE Test

ELECTROSTATIC DISCHARGE (ESD)

It is the transfer of an electrostatic charge between bodies at different electrical potential. It is also called static electricity. Information about ESD immunity test is described in IEC 61000-4-2 standard. Its purpose is to determine the immunity of systems to external ESD events outside of the system during operation. There are two types of ESD test contact discharge and air discharge. In contact discharge there is direct contact between electrode of the test generator and EUT and in AIR discharge there is no direct contact between discharge electrode of gun and EUT. Contact discharge is most preferable method than air discharge. During the test ten positive and ten negative pulses of interval one second is applied to EUT.
As per IEC 61000-4-2 Air discharge shall be used where contact discharge cannot be applied [1].

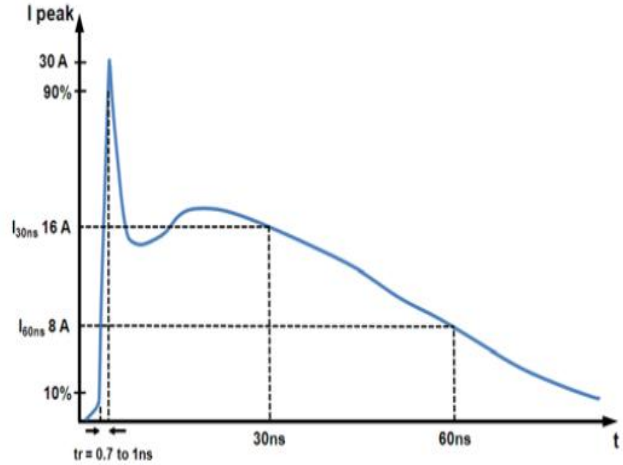

Fig1: IEC 61000-4-2 ESD Waveform

ELECTRICALLY FAST TRANSIENT (EFT)

EFT is number of extremely fast transient. It is originated from the switching activity. Information about immunity test of EFT is describe in the standard IEC 61000-4-4.Its purpose is to simulate the effect of fast, repetitive transient burst on incoming power supply lines and cable lines. These fast burst transient are coupled onto the communication line using capacitive clamp. This also reduces the loading [2].

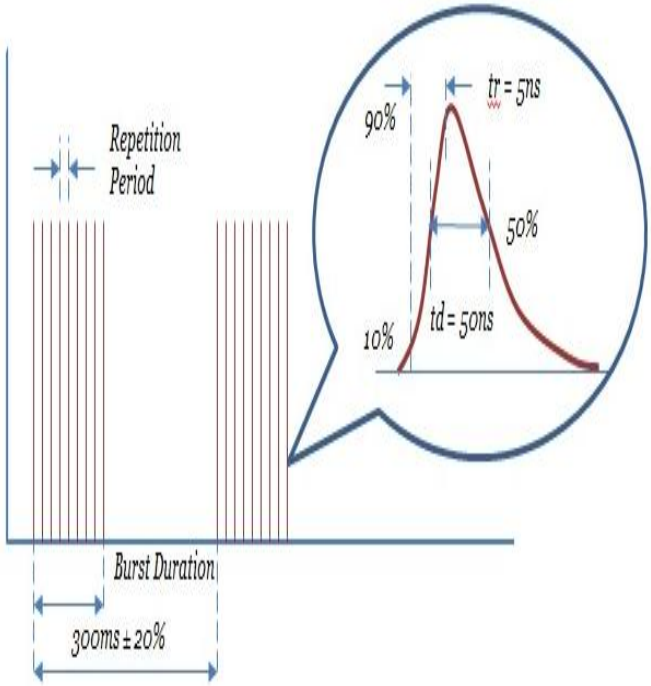

Fig2: EFT Waveform

SURGE

A surge is a steep transient rise of voltage of very short duration (µs) in an electrical system. It occurs due to the external reason(Lightning) or Internal reason(switching of reactors or capacitors).Information about immunity test of surge is describe in IEC 61000-4-5 standard. Its purpose is to simulate the effect of voltage surges on AC and DC power supply lines, unshielded and shielded communication line caused by switching transient and lightning transient [3].

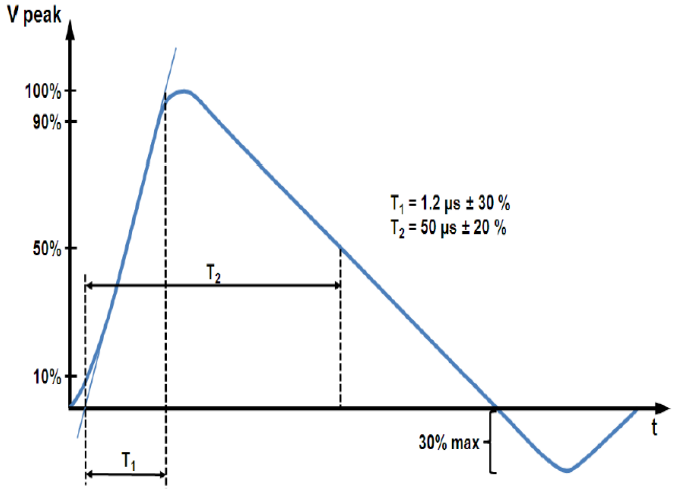

Fig3: IEC 61000-4-5 Surge Waveform

PASS / FAIL CRITERIA

When transient are applied to Equipment under test (EUT), then result of test are classified into four criteria A, B, C, D.

CRITERIA	CONDITION
A	Device will work properly without any error
B	When transient is applied and device is in malfunction and return to its normal operation without operator.
C	When transient is applied and device is in malfunction and return to its normal operation with operator help.
D	Function loss and EUT will damage permanently

Table2: Pass/Fail Criteria.

Most of the cases class A criteria is expected sometimes B is also accepted depends on working condition. We will not expect criteria D[1][2][3].

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TRANSIENT PROTECTION

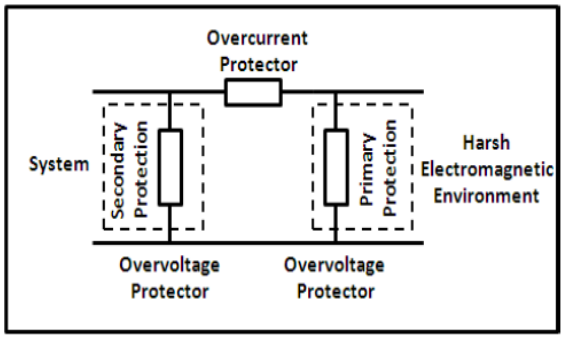

Fig4: General Block diagram of protection method

Fig shows block diagram of protection scheme. It shows that before entering transient into the system it has to face three obstacles. Primary protection level diverts most of transient energy away from the system and it divert transient to ground. Secondary protection circuit protects the system against the system which are passed through primary protection. There must be coordination occur between primary and secondary for that purpose over current protector or resistor is used.

METHOD 1

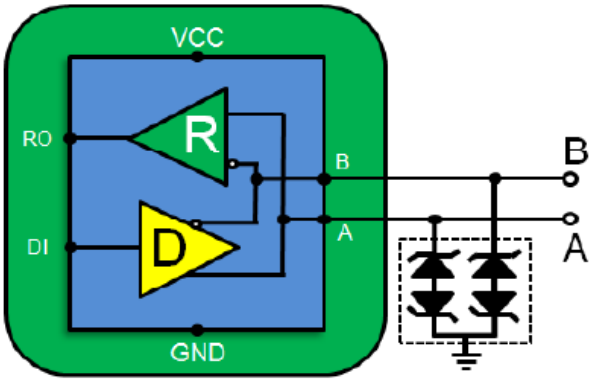

Fig 5.Method 1

STANDARD	LEVEL	VOLTAGE
ESD(-4-2)	4	8KV/15KV
EFT(-4-4)	4	2KV
SURGE(-4-5)	4	1KV

Table 3: Method 1 transient voltage level.

The first method can protect up to level 4 ESD and EFT and level 2 surges. In this method we have used transient voltage suppressor (TVS) array, which consists of two bidirectional TVS diodes used to protect RS 485 system. A TVS is a semiconductor based device under normal operating condition it is having very high impedance i.e. open circuit. When transient voltage is larger than breakdown voltage of the TVS, then TVS clamps the transient to a voltage below breakdown voltage of the protecting circuit. The transient are clamp with very short time (<1ns) and the transient current is diverted away from the protected device to ground [4].

METHOD 2

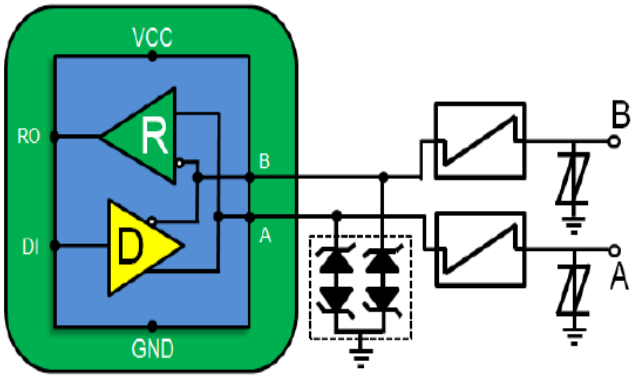

Fig6.Method 2

STANDARD	LEVEL	VOLTAGE
ESD(-4-2)	4	8KV/15KV
EFT(-4-4)	4	2KV
SURGE(-4-5)	4	4KV

Table 4: Method 2 transient voltage level.

Method 1 can provide protection up to level 4 of ESD and EFT and level 2 of surge. In method 2 we can provide protection up to level 4 of transient. Above fig. circuit consists of TVS, Transient blocking Unit (TBU), and Totally Integrated Surge Protector (TISP).TVS is used as secondary protection device and TISP is used as primary protection device and to coordinate between primary and secondary device over current protection circuit TBU is used and TBU provide protection for TVS.

A TBU is a high speed over current protection device and it has defined current limit and it can sustain high voltage. In normal operating condition it is having low impedance and in blocking mode it is having high impedance to transient. When transient occur TBU disconnect the equipment in very short time and then for remaining part of transient TBU will operate in blocking state with very low current passing through equipment.

TISP can be used as primary protection device it clamp the voltage and divert the transient energy to ground. Commonly used primary protection devices are gas discharge tube (GDT) or solid state thyristor like TISP, when voltage increases above defined level, it provides a low impedance path to ground diverting majority of transient energy away from protected circuit and other protection devices. TISP has discontinuous and non linear V-I characteristics.

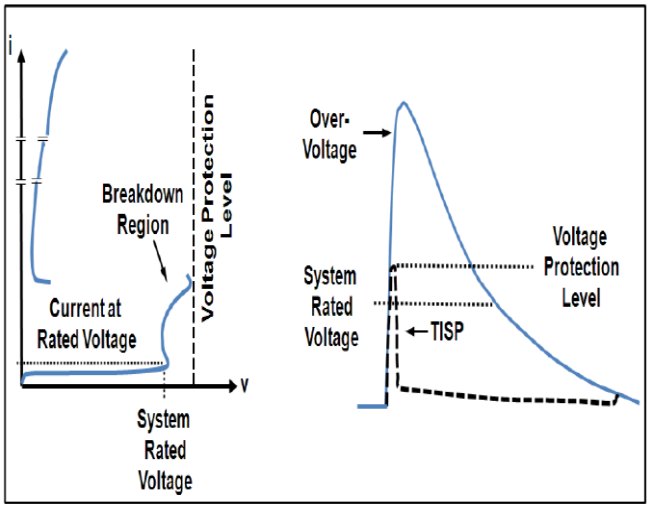

Fig 7.V-I characteristic of TISP

As shown in fig clamping action is taking place due to avalanche breakdown because TISP moves from over voltage state to low voltage state diverting transient energy. When diverted current goes below critical then TISP reset automatically in normal operation.

METHOD 3

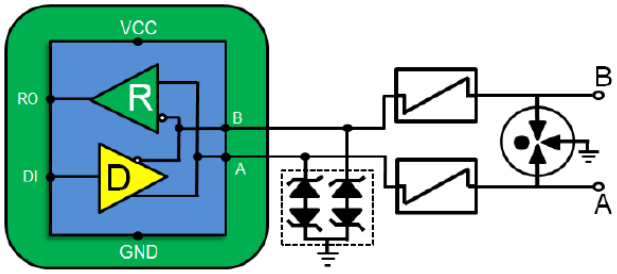

Fig8.Method3

STANDARD	LEVEL	VOLTAGE
ESD(-4-2)	4	8KV/15KV
EFT(-4-4)	4	2KV
SURGE(-4-5)	X	6KV

Table 5: Method 3 transient voltage level.

Method 2 can provide protection up to level 4 of ESD, EFT and surge. There are some situation where surge may exceed than level 4 at that time method 3 is used it provides protection up to level 4 ESD,EFT and up to 6KV surge transients. In this method GDT is used as a primary protection device which protect other devices also i.e.TBU and TVS .GDT can provide more protection to over current and overvoltage than TISP.When transient voltage is equal to spark over voltage then GDT will move from high impedance off state to arc mode. In arc mode the GDT will becomes a virtual short providing path to current and divert transient current away from the protected device.

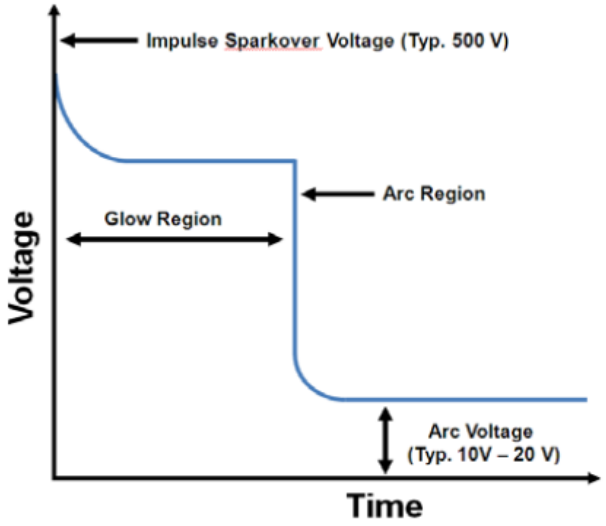

Fig9.Characteristic of GDT

In glow region the gas in the tube starts to ionize due to charged developed across it when voltage across GDT increases. In this region because of increased current flow avalanche effect will take place and GDT will become virtual short. During the short circuit event the voltage developed across device is known as arc voltage.

CONCLUSION

While designing any electronic circuit from simplex to complex the effect of these transient should be taken into account. Out of three transient surge is having more energy. By considering this transient at the time of design we can save time as well as money.

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