EMI Suppression KTA1550, KTA1552 - FAQ

1. What is EMC?

Electro-magnetic Compatibility (EMC) – the capability of electrical and electronic systems, equipment, and devices to operate in their intended electro-magnetic environment within a defined margin of safety, and at design levels or performance, without suffering or causing unacceptable degradation as a result of electromagnetic interference. (ANSI C64.14-1992)

2. What is EMI?

Electromagnetic interference (EMI) – sometimes it is also called radio frequency interference (RFI). Even though the radio frequency means 10kHz to 100GHz, useful for communication purpose. Electromagnetic waves include all frequency ranges from DC to sunlight, i.e., electrostatic discharge (ESD). EMI is a disturbance transmitted from one device to another by either radiation or conduction. The unwanted disturbance energy might cause degradation in performance or interruption or damage of the affected devices. EMI can be created intentionally or unintentionally.

3. What is Radiated Emission (RE)?

Radiated emission happens when the energy is transmitted through free space.

4. What is Conducted Emission (CE)?

Conducted emission happens when the energy is transmitted through conductors, i.e., wire, cable, PCB traces, connectors, power cord, etc.

5. What is immunity?

Immunity means the ability for a device to perform within the spec while EMI exist.

6. What is radiated immunity?

Radiated immunity means that the ability for a device to perform within the spec while radiated interference exists.

7. What is conducted immunity?

Conducted immunity means that the ability for a device to perform within the spec while conducted interference exists.

8. What is EMI suppression?

EMI suppression is the feature/ability of a component to reduce EMI (reduce emissions and/or increase immunity) of a system in order to meet the EMC performance.

9. What is common mode noise?

It is the component of RF energy that is present on both signal and return paths in phase. No current flows in the load because there is no potential difference across it. All common mode current flows to ground via parasitic capacitance between the cable and the ground.

10. What is differential mode signal?

It is the component of RF energy that is present on both signal and return paths with 180º phase shift. No current flows to ground. All current flows through the load. The instantaneous sum of the differential voltages is always zero.

11. What does Ethernet Transformer look like?

It is a pulse isolation transformer with built in 2- or 3-line Common Mode Choke and / or an autotransformer (serves as shunt choke and center tap for power steering).

12. What is impedance ratio of a transformer?

Impedance ratio is inversely proportional to the square of turns ratio.

13. What is the function of a pulse transformer?

a. Electrical isolation per IEEE 802.3
b. Transfer of Ethernet signals without distortion
c. EMI suppression

14. What is a Common Mode Choke?

A common mode choke is a pair of wires wound on the ferrite core, in phase. Impedance is nonlinearly proportional to the winding inductance.

15. How does a Common Mode Choke work?

Within phase winding, when differential signal is present, net current is zero, net flux is zero and hence the net winding inductance is zero. So, the CM choke presents no impedance to the differential signal.

When common mode signal is present, two winding currents are in phase and net current is not zero, net flux is non-zero. So, the CM choke has considerable impedance and that reduces transmission of common-mode signal to the other side of CM choke.

16. What does a Common mode Choke model look like?

It is a choke in series with both the signal line and its return path. It presents a common mode inductance and resistance paralleled with a common mode capacitance which limits CM choke high frequency impedance.

17. What transformer elements affect differential mode signal?

- Turn ratio
- Magnetizing inductance
- Leakage inductance
- Distributed and inter-winding capacitance
- Winding resistance

18. What transformer elements affect common mode suppression?

- Center tap balance
- Series impedance in the connection between the center tap and reference (CT inductance + center tap capacitance)
- Inter-winding capacitance
- CM choke impedance

19. What is an autotransformer?

An autotransformer is so called because it consists of only one winding, and the energy transfer through the device is affected by direct current transfer. It is designed just like a common-mode choke but by winding the wires out-of-phase.

An autotransformer presents high impedance to differential signal because a differential signal sees the two halves of the center tapped autotransformer with the windings in phase with the signals.

An autotransformer presents zero impedance for common mode signal because a common mode signal sees the two halves of the center-tapped autotransformer with the windings in anti-phase. That means the net flux generated by the common mode currents is zero, so the inductance of the autotransformer to the common mode noise is zero. An ideal autotransformer shunts the common mode noise to ground directly.

Due to its filtering function to common mode noises through shunting it between the signal lines, it is also called a Shunt Choke. Autotransformer also have many other different names, i.e., autoformer, zero, etc.

20. What are the modes of propagation on UTP?

a. Intentional propagation: DM propagation between two wires of each pair
b. Unintentional propagation:
   - Mixed CM / DM propagation between pairs – signal looks common- mode on one pair of wire, but finds return path on another pair within the same cable bundle. So, at cable level propagation mode is still differential.
   - CM propagation between pairs and environment – signal is purely common-mode on the full pair and it finds return path through the environment.

21. How does intentional DM propagation relate to EMI?

Mostly the opposing currents produce equal and opposite polarized magnetic fields and cancel out each other's EM field, resulting in very low EMI.

If the two wires in a given pair are not identically wound, the generated magnetic fields will not be exactly equal and opposite and so will not exactly cancel. This asymmetry gives rise to EMI radiation. This process is called "differential to common mode conversion."

Differential mode signals do not directly generate EMI in UTP cable systems.

22. How does unintentional mixed CM/DM propagation relate to EMI?

It is different from pure CM propagation because CM/DM propagation is contained within the cable. Thus, it doesn't have major impact on EMI.

23. How does the pure CM propagation relate to EMI?

The currents generate magnetic fields with equal magnitude and polarity, which do not cancel each other out. It has the highest potential to cause EMI because propagation is between the cable and the environment. The main EMI-related function of magnetics is to suppress this mode of propagation.

24. Why does CM signal create radiation?

A common-mode signal flowing through a cable does not have a defined and direct return path. Return of common-mode current happens via parasitic coupling to closest available earth ground in the environment. Hence the cable parasitically coupled to an "environment" return path forms a loop antenna, and converts common-mode propagation to radiated emission.

25. How has the CM been suppressed by CM Choke?

An ideal CM choke is an inductive element where the common-mode impedance increases with frequency. Depending on target frequency where common-mode suppression is desired, inductance value/size is determined. However, in real choke, there is always parasitic capacitance across the inductive element. This capacitance is a function of number of turns and winding style, and limits impedance on the choke at higher frequencies. So, it is a passive component with band-pass behavior where common-mode impedance is high and good common-mode rejection is achieved. Actual bandwidth of use depends on the specific CM Choke selected.

Also because of use of ferrite materials and hand winding, common-mode chokes are bulky and have highly variable performance.

26. Why is an Active EMI Suppressor necessary?

An Active EMI Suppressor is needed when the adaptive and continuous suppression of common mode noises is required over the entire Ethernet Signal bandwidth. And/or EMC Class B emissions or Level 2 or higher EMI immunity required.

27. How does the Active EMI Suppressor Work?

The KTA1550 & KTA1552 are IP-protected analog ICs which provides high impedance for differential signal and extremely low impedance for common mode signal. It compensates for many variables that are the source of common-mode noise in Ethernet Systems.

28. How does Active EMI Suppressor like the KTA1550 & KTA1552 improve system level EMI performance?

The KTA1550 & KTA1552 absorb all the common-mode noise on differential pairs because it has very low common-mode impedance to the ground. So, any noise coming from the Ethernet PHY side can be absorbed by the KTA1550 or KTA1552 before it gets to the RJ45/cable.

Any common mode noise coming from the UTP cable will be absorbed by the KTA1550 or KTA1552 before it gets to the Ethernet PHY receiver. That will prevent bit-errors on the Ethernet link, providing good EM Immunity.

29. Does the Active EMI Suppressor create any additional stubs?

No. The Active EMI Suppressor provides flow-through routing pads for ease of routing.

30. What is the loading capacitance of the Active EMI Suppressor?

It is 4.5pF differential (typical).

31. What is the suppression bandwidth of the Active EMI Suppressor?

The Active EMI Suppressor provides suppression over a frequency of 1MHz to 125MHz, which covers the main Ethernet signal band (for 10/100/1000Base-T systems) and first clock harmonic at 125MHz.

32. How much current does the Active EMI Suppressor consume?

The total current consumption is about 47mA, of which about 42mA is provided by Center tap power supply.

33. How much does the Active EMI Suppressor suppress the common mode noise?

It depends on the mode of the KTA1550 or KTA1552 operation. Under default operation mode, it provides over 10dB suppression over the entire Ethernet signal bandwidth. This suppression is in addition to the suppression achieved by the transformer itself based on it's autoformer and choke combination.

34. How does the Active EMI Suppressor help balance of DM lines?

Imbalance of DM lines can be caused by many factors, i.e., asymmetry of UTP cable material and winding / PCB DM trace routing and coupling parasitics / transformer center tap location, differential I/Os of IC, tolerance of matching elements, etc. The imbalance of DM lines exists in any system and it causes differential signals on the lines partly converted into common mode noise more or less depending on the IC and system level designs. The KTA1550 or KTA1552 appear as low impedance for common mode propagation. Thus, the KTA1550 or KTA1552 suppresses EMI due to differential mode to common mode conversion and bring the DM lines into the state of balance.

35. Is there any caution to using an Active EMI Suppressor?

Because the additional current required from the center tap, the power supply / ferrite bead sizes have to be verified in adopting the performance improvement.

The KTA1550& KTA1552 are designed to maintain differential signal integrity in the Ethernet signal path. However, whenever there is an additional component added in the system, parasitic capacitance can cause slight degradation of system return loss performance. Performance should be validated and tuned as necessary. Details on return loss tuning are available through application notes.

Related Documentation

1. KTA1550 Datasheet
2. KTA1552 Datasheet
3. AN093: KTA1550 Design Guide
4. AN094: Meeting Ethernet Return Loss Requirements with the KTA1550
5. AN095: How to Design Kinetic Technologies KTA1550 for use with Voltage-mode PHYs

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