Receiver Common-Mode Noise Rejection ad hoc report

IEEE P802.3bq 40GBASE-T Task Force

Pete Cibula (Intel)
Rx CMNR ad hoc chair

Pittsburgh, PA - May 2015

Rx CMNR ad hoc charter and scope/deliverables

- Investigate the receiver common mode noise rejection (Rx CMNR) test, also known as the cable clamp test, and define an appropriate requirement for 40GBASE-T PHYs.

- Develop corresponding text for IEEE P802.3bq, subclause 113.5.4.3 Common mode noise rejection and any associated Annexes.

Next Steps
(From March 4th, 2015 ad hoc meeting)

- Agree on minimal text to include during P802.3bq Draft 1.2 comment resolution
- Include minimal text in ad hoc report; follow up with motion to adopt the minimal text during discussion of Comment #237

Done!

Done!

- Continue technical work in the ad hoc to refine details of implementation
  - Submit updates as comments in upcoming Working Group ballot(s)

We are here!

Rx CMNR ad hoc activity since Berlin meeting

- Two Rx CMNR ad hoc calls – April 1st and April 28th, 2015.
  - May 13th meeting slot was yielded to the PHY ad hoc

- Meeting minutes and contributions are available at the 40GBASE-T website Receiver Common-Mode Rejection ad hoc area (http://www.ieee802.org/3/bq/public/rxcmr/index.html)

- Meeting highlights
  - Reviewed new ferrites to prevent significant induced currents from propagating to the far side in order to reduce test variability
  - Reviewed correlation studies between cable clamp and representative radiated immunity tests
  - Reviewed a proposal for an informative Annex to support Clause 113.5.4.3 and developed text to be reviewed during P802.3bq D2.0 comment resolution.
    - Text reviewed in the April 28th ad hoc meeting is included at the end of this report for reference.

Rx CMNR ad hoc next steps

- Further work
  - Continue technical work in the ad hoc to refine details of implementation
  - Submit updates as comments in upcoming Working Group ballot(s)
- Next meetings
  - Meetings will be scheduled on alternate Wednesdays at 9:30AM PDT between now and the July plenary meeting
- Thanks to all ad hoc participants and contributors – and remember… you, too, can be a contributor!

Thank You!

Proposed Informative Annex 113A

- As suggested in previous discussion comments, it is critical that the test conditions be well controlled.
- Clause 40 included Annex 40B to address this issue, and it is (or at least, is believed to be) generally accepted as a good solution to this issue.
- The attached Annex 113A is based on Annex 40B, with appropriate updates for 40GBASE-T technology (cable diameter, frequency range) and some potential improvements in the calibration and setup.
  - Most source-adjustment criteria, measurement points, and levels used with the clamp methodology in this subclause are defined in this Annex.
  - Other considerations, such as alternate distances between the clamp and MDI, can be easily accommodated in this Annex as we complete additional investigations to refine an representative implementation of the clamp methodology.
- A mark-up is available for review at the Rx CMNR ad hoc section of the P803.bq project site.
- Proposed, *not final,* Annex 113A text is repeated on the following slides

Key Elements of the Annex

- Description of cable clamp and test setup
  - What's in here
  - Description, dimensions and electrical characteristics (IL, RL) of the clamp
- Cable clamp validation
  - Procedure to verify clamp performance
    - Confirm that the induced common-mode and differential-mode noise levels on the cable do not exceed maximum limits
- Test Setup
  - Representative implementation to provide guidance on the test configuration, measurement points and levels

Annex 113A (informative)
Description of cable clamp and test setup

Annex 113A Description of cable clamp and test setup

(informative)

Overview

- This annex describes a cable clamp and a representative methodology that should be used in the rejection of external EM fields test of 113.5.4.3, which is used to determine the sensitivity of the PMA receiver to external EM fields picked up by the cabling and interconnect system.

Description of cable clamp

Description of cable clamp

- As shown in Figure 113A-1 and 113A-2, the clamp is 300 mm long, 75 mm wide, 78 mm high with a center opening of 9.525 mm (0.375 in). The clamp consists of two halves that permit the insertion of a cable into the clamp.
- The clamp has a copper center conductor and an aluminum outer conductor with a high density polyethylene dielectric. The following is a review of the construction and materials of the clamp:
  - a) Inner conductor - Copper tubing with an inner diameter of 9.53 mm (0.375 in) and an outer diameter of 12.7 mm (0.50 in).
  - b) Outer conductor - Aluminum bar that is 300 mm long and approximately 78mm by 75mm. The bar is milled to accept the outer diameter of the dielectric material.
  - c) Dielectric - High Density Polyethylene (Residual, TypeF) with dielectric constant of 2.32. The hollow cylinder has an outside diameter of 45 mm and an inner diameter that accepts the outside diameter of the copper inner conductor.
  - d) Connectors - BNC connectors are located 9 mm (0.39 in) from each end of the clamp and are recessed into the outer conductor. The center conductor of the connector is connected to the inner conductor as shown in Figure 113A-2.
  - e) Clamping screws - Six screws are used to connect the two halves of the clamp together after the cable has been inserted. Although clamping screws are shown in Figure 113A-1, any clamping method may be used that ensures the two halves are connected electrically and permits quick assembly and disassembly.
  - f) Nylon screws - Used to align and secure the inner conductor and dielectric to the outer conductor. The use and location of the screws is left to the manufacturer.
  - g) Keying bolts - Two studs used to align the two halves of the clamp.
- As shown in Figure 113A-2 the inner conductor on the bottom half of the clamp extends slightly (~ 0.1mm) above the dielectric to ensure there is good electrical connection with the inner conductor of the top half of the clamp along the full length of the conductor when the two halves are clamped together.
- The electrical parameters of the clamp between 80MHz and 2GHz are as follows:
  - a) Insertion loss: <5 dB
  - b) Return loss: >20.0 dB (80MHz-520MHz), $20.5 - 50\log_{30}(f/500)$ dB (520MHz-2000MHz)

Cable Clamp Construction

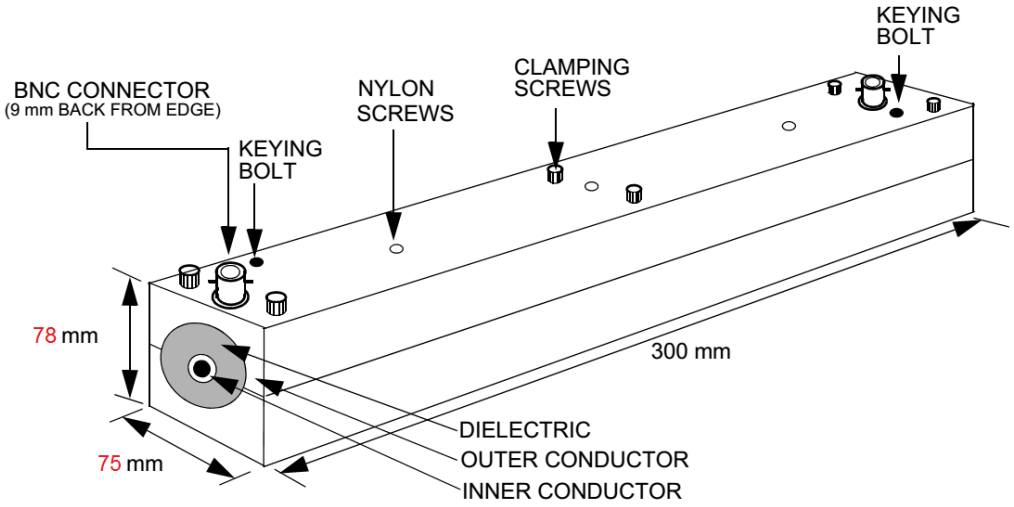

Figure 113A-1 - Cable clamp

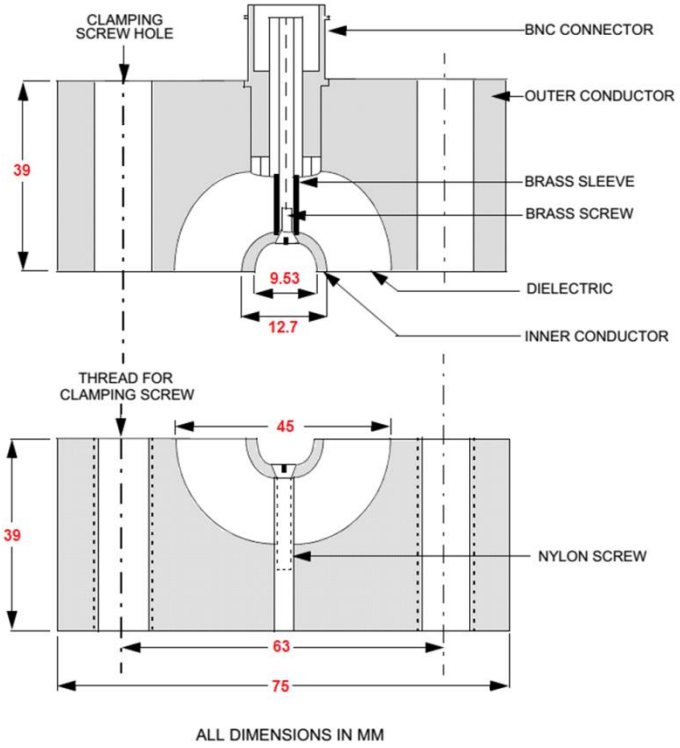

Figure 113A-2 - Cross-section of cable clamp

Annex 113A.1 Cable clamp validation (1)

- In order to ensure the cable clamp described above is operating correctly, the following test procedure is provided. Prior to conducting the following test shown in Figure 113A-3, the clamp should be tested to ensure the insertion loss and return loss are as specified above. The cable clamp validation test procedure uses a well-balanced 4-pair Category 8 test cable or better that meets the specifications of 113.7.

- The test hardware consists of the following:
  - a) Transmitter/Receiver – A link partner system, configured for the data rate being evaluated, with the transmitter disabled.
  - b) Breakout Fixture – A passive fixture with a modular jack input and individual outputs for each of the 8 signal wires. Wires of pairs not being measured should be terminated to the ground plane with a 50 Ω resistor.
  - c) Balun - 3 ports, laboratory quality with a 100 Ω differential input and a 50 Ω single-ended, unbalanced output:
    - Insertion Loss (100 Ω balanced <-> 50 Ω unbalanced): <4dB (1MHz-3GHz)
    - Return Loss: >30dB (1MHz-3GHz)
    - Common-Mode Rejection: >60dB (1MHz-200MHz), >30dB at 3GHz
  - d) Test cable - 4-pair 100 Ω S/FTP Category 8 balanced cable at least 30 m long.
  - e) Chokes (5) - Wideband Ferrite Material:
    - Inner diameter: 8.7 mm to 10.15mm
    - Impedance: 175 Ω @ 100 MHz, 275 Ω @ 250 MHz, 375 Ω @ 500 MHz, 400 Ω @ 1000 MHz
  - f) Ground plane - Copper sheet or equivalent.
  - g) Signal generator
  - h) Signal Sensor & Measurement System - Oscilloscope, power meter or spectrum analyzer
  - i) Receiver

Annex 113A.1 Cable clamp validation (2)

- With the test cable inserted in the cable clamp, a signal generator with a 50 Ω output impedance is connected to one end of the cable clamp and a signal sensor with a 50 Ω input impedance is connected to the other end. The signal generator shall be capable of providing a sine wave signal of 80 MHz to 2GHz. The output of the signal generator is adjusted for a signal power of 6dBm at 80 MHz on the signal sensor. The remainder of the test is conducted without changing the signal generator voltage. The cable pairs not connected to the balun are terminated in a resistor network. It is very important that the cable clamp, breakout fixture and balun have good contact with the ground plane. The chokes, which are located next to each other, are located approximately 2.0 cm from the clamp. The cable between the clamp and the balun should be straight and not in contact with the ground plane.

- The differential-mode and common-mode voltage outputs of the balun and breakout fixture should meet the limits shown in Table 113A-1 over the frequency range 80 MHz to 2GHz for each cable pair.

- NOTE - Prior to conducting the validation test the cable clamp should be tested without the cable inserted to determine the variation of the signal generator voltage with frequency at the output of the clamp. The signal generator voltage should be adjusted to 6dBm at 80 MHz on the signal sensor. When the frequency is varied from 80MHz to 2GHz, the measured power should not vary more than ±10%. If the power varies more than ±10%, then a correction factor must be applied at each measurement frequency.

Annex 113A.1 Cable clamp validation (3)

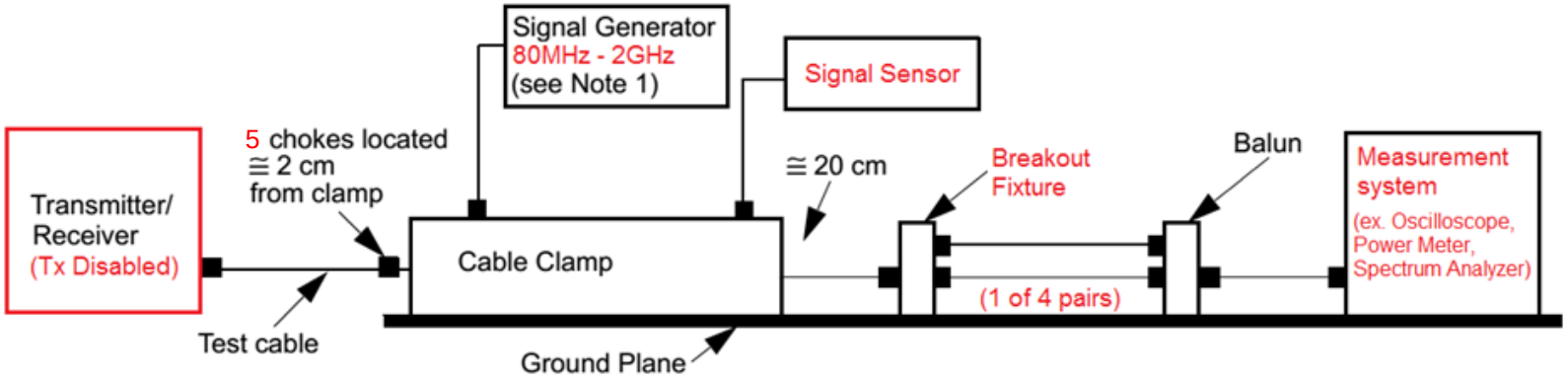

Figure 113A-3 - Cable clamp validation test configuration

Table 113A-1 - Common- and differential-mode output voltages

Frequency (f)	Common-mode voltage	Differential-mode voltage
80-250 MHz	<1.07 – 0.6 (f-80)/170 Vpp	<22 mVpp (-29 dBm)
250MHz-2GHz	<470mVpp (-2.6dBm)	<22mVpp

Annex 113A.2 Test Setup

- An up to 30-meter, 4-pair Category 8 channel that meets the specification of 113.7 is connected between two 40GBASE-T PHYs and inserted into the cable clamp. The cable should be terminated on each end with an MDI connector plug specified in 113.8.1. The clamp should be located a distance of ~20 cm from the receiver. It is recommended that the cable between the transmitter and the cable clamp be installed either in a linear run or wrapped randomly on a cable rack. The cable rack should be at least 3 m from the cable clamp. In addition, the cable clamp and 40GBASE-T receiver should be placed on a common ground plane and the ground of the receiver should be in contact with the ground plane. The chassis grounds of all test equipment used should be connected to the ground plane. No connection is required between the ground plane and an external reference. A signal generator with a 50Ω impedance is connected to one end of the clamp and measurement equipment with a 50Ω input is connected to the other end of the clamp. The signal generator shall be capable of providing a sine wave signal of 80 MHz to 2 GHz. The output of the signal generator is adjusted for a signal power not to exceed 6 dBm at the signal sensor to simulate an external electromagnetic field of approximately 3 V/m.

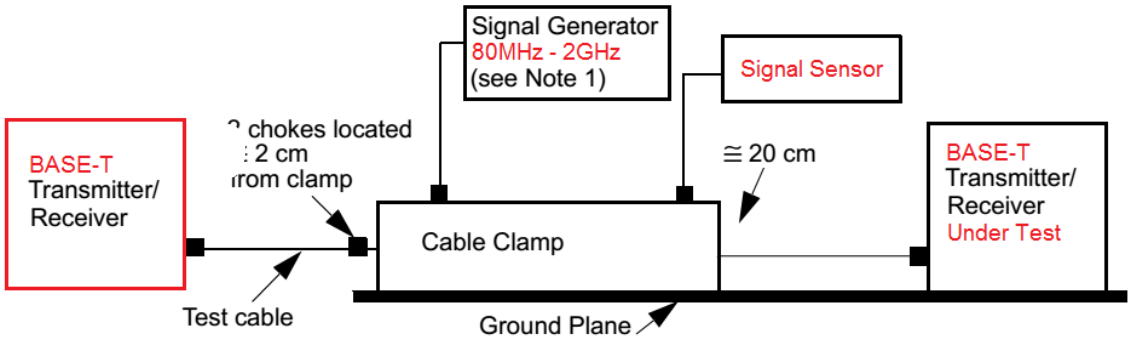

Figure 113A-4 - Cable clamp test configuration