Annex 113A Description of cable clamp and test setup

(informative)

113A.1 Overview

This annex describes an example of a cable clamp and ~~a~~ a representative methodology that should be used in common-mode noise rejection, ~~the~~ rejection of external EM fields, or similar MultiGBASE-T receiver tests using EM clamp injection techniques ~~of 113.5.4.3~~, which ~~is~~ are used to determine the sensitivity of the PMA receiver to external EM fields ~~picked up~~ introduced by the ~~MDI connector and the~~ cabling and interconnect system. Variations of this methodology may also be useful for other testing as applicable ~~may be suitable~~ for design and development purposes. Refer to the receiver specifications of the PHY under test for specific impairments, impairment source power levels, and relevant frequency ranges.

113A.2 Description of c~~C~~able c~~C~~lamp

(Note – The larger inner diameter clamp is described here; see Annex 40B for the description of an alternate clamp for use with smaller diameter cable types)

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.

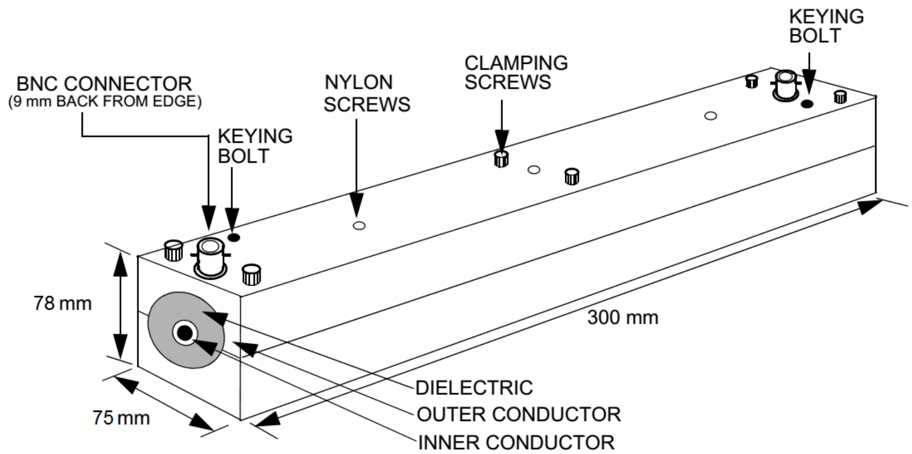

Figure 113A-1 - Cable clamp

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).

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b) *Outer conductor* - Aluminum bar that is 300 mm long and approximately 78 mm by 75 mm. The bar is milled to accept the outer diameter of the dielectric material.

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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.

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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.

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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.

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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.

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g) *Keying bolts* - Two studs used to align the two halves of the clamp.

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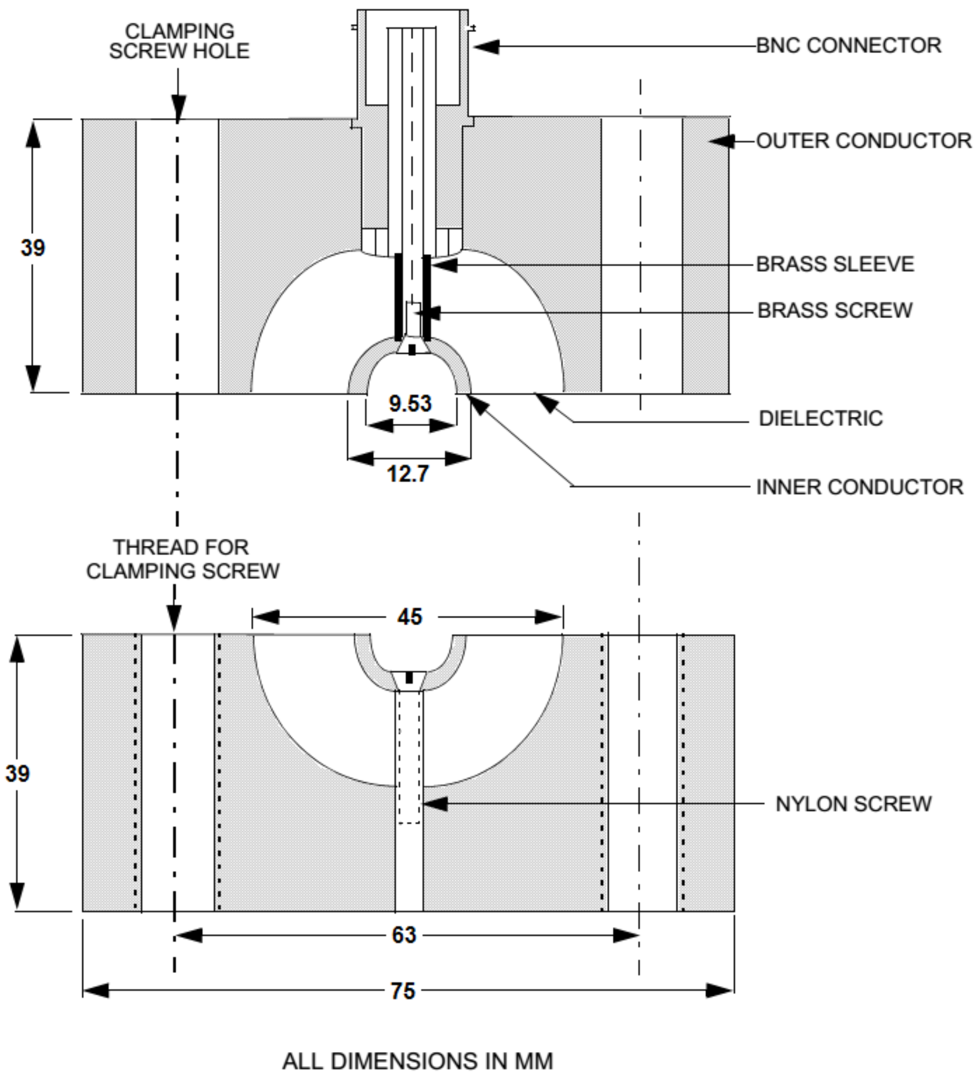

Figure 113A-2 - Cross-section of cable clamp

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 80 MHz and 2 000 MHz are as follows:~~

a) Insertion loss: < 5 dB

b) Return loss: >20.0 dB (1 MHz-520 MHz), >20.5 – 50log30(f/500) dB (520 MHz-2 000 MHz)

The electrical parameters of the clamp between 1 MHz and 2 000 MHz are defined in Table 113A-1.

Table 113A-1 – Cable clamp electrical parameters (1 MHz – 2 000 MHz)

Frequency range	Insertion Loss	Return Loss
1 MHz - 250 MHz	< 0.2dB	> 20.0 dB
250 MHz - 500 MHz	< 1.0 dB	> 7.0 dB
500 MHz - 1 000 MHz	< 3.5 dB	> 3.5 dB
1 000 MHz - 2 000 MHz	< 15.0 dB	> 1.0 dB

113A.1 2 Cable clamp Clamp validationMeasurement

In order to ensure the cable clamp described above is operating correctly, the following test validation procedure iss are provided. Prior to conducting the following these tests shown in Figure 113A-3, the clamp should be tested measured to ensure the insertion loss and return loss are as specified abovebelow. The electrical parameters of the clamp are measured between the source connections and without installed cabling to verify proper operation and so that the Insertion Loss results can be used for testing. Measurement results should meet the following:

a) Insertion loss: < 1 dB below 500 MHz, < 3.5 dB below 1000 MHz, < 15 dB below 2000MHz

b) Return loss: > 7 dB below 500 MHz, > 3.5 dB below 1000 MHz, > 1 dB below 2000 MHz

113A.33 25/40G SetupCable clamp vValidation

In order to ensure the cable clamp is operating correctly, the following measurement and validation procedures are provided and should be completed prior to conducting the test described in 113A.4 and illustrated in Figure 113A-4.

Cable clamp electrical measurement - The clamp should be measured to ensure the insertion loss and return loss are as specified in 113A.2. Electrical parameters of the clamp are measured between the source connections and without cabling (that is, no cabling inserted in the clamp inner conductor).

Cable clamp validation – This validation procedure is provided to verify proper operation of the test setup before performing any tests. In contrast to the clamp electrical measurement, tThehise cable clamp validation test procedure uses the clamp with shielded cabling that meets the the specifications of PHY link segment specifications inserted into the clamp113.7.

The validation test hardware consists of the following:

Comment [CPR1]: Ad hoc discussions suggested restoring the original text, and then adding the measurement section for clarification. Possibly re-format as a table?

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Comment [CPR2]: Note: The ad hoc had quite a bit of discussion about specifically calling out rates in these two sections. Is there a better way to manage that? Suggestion to explicitly identify the general usage cases up front; as an example, look at George's comment and suggested remedies for guidance. Part of the issue is that there may be different frequency ranges for different rates/PHYs and whatever is adopted should accommodate this reality. One example is the next line.

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~~an MDI connector 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~~ 4 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 (1 MHz-~~3~~ 2 000 MHz)

Return Loss: > 8dB (1 MHz- 3 MHz), > ~~30dB~~ 15dB (~~1~~ 3 MHz-~~3~~ 2 000 MHz)

Common-Mode Rejection: > ~~60dB~~ 50dB (1 MHz-1 0~~2~~00 MHz), > ~~30dB~~ 40dB at ~~3~~ 2 000 MHz

Common-Mode Return Loss > 8 dB (1 MHz-2 000 MHz)

d) 50 Ω r~~R~~esistor~~-~~s ~~terminations –~~ Used to terminate ~~for the~~ unmeasured conductors.

e) Test cable – A 30m, 4-pair 100 Ω plug terminated~~-~~ cable that meets the PHY link segment specifications~~shielded cable that meets the requirements of 113.7; for example, S/FTP Category 8 balanced cable~~.

~~e~~f) Chokes (5) - Wideband Ferrite Material:

~~Inner diameter: 8.7 mm to 10.15mm~~

Inner diameter: Selected to minimize the gap between the ferrite and the cable used for the test.

Impedance: 175 Ω @ 100 MHz, 275 Ω @ 250 MHz, 375 Ω @ 500 MHz, 400 Ω @ 1 000 MHz

~~f~~g) Ground plane - Copper sheet or equivalent large enough to span the equipment interface under test and the clamp, including the portion of the cable between the equipment and the chokes.

~~g~~h) Signal generator capable of providing a sine wave signal of 1~~80~~ MHz to 2 000 MHz.

~~h~~i) Signal Sensor & Measurement System - Oscilloscope, power meter or spectrum analyzer with at least ~~4~~ 4 ~~2~~ 000 MHz bandwidth

~~i~~j) Receiver

Comment [CPR3]: Ad hoc discussion focused on how to generalize this description. 30m was selected as it is the max link segment for 40GBASE-T; is this appropriate for other PHY types? (i.e. max link segment for other rates/PHYs). Note that corresponding IEC tests accommodate other lengths, but is it necessary? Noting that 30m is the upper bound for 25/40; the analog would be 100m on 10G. Annex 40B calls out "category 5 balanced cable at least 30m long." We can take advantage of this length – 30m provides happy coincidence and will be retained.

Comment [CPR4]: Ad hoc discussion concerned using ferrites that would allow a significant gap between the I.D. and the cable. The inner diameter was re-written with language indicating that the I.D. should be suitable and fit over the category being used for the test; something like "appropriate for the cable used for the test."

Comment [CPR5]: Restored 4GHz minimum bandwidth since we are measuring a 2GHz signal.

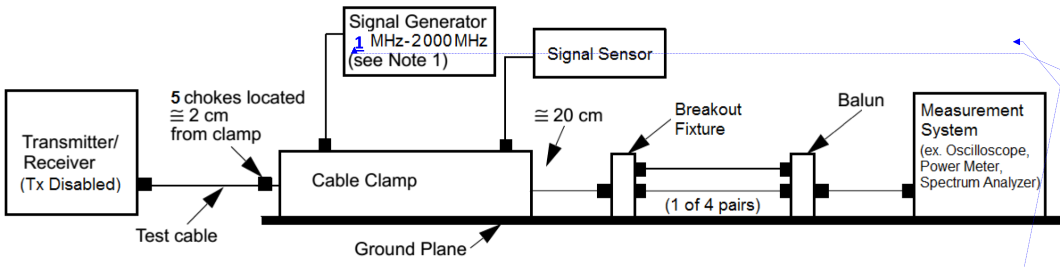

Figure 113A-3 - Cable clamp validation test configuration

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~~ 1 MHz to 2 000 MHz. The output of the signal generator is adjusted for the specified~~a~~ signal power ~~of 6dBm~~ at ~~80~~ 20 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 t~~The cable clamp, breakout fixture and balun must ~~have good direct low inductance~~ be in direct contact with the ground plane in a manner consistent with good RF measurement practices.~~-~~ The chokes~~, which~~ are placed on the cable, located next to each other and ~~, are located~~ approximately 2.0 cm from the clamp.

The cable between the clamp and the ~~balun~~ breakout fixture should be positioned straight from the clamp to the breakout port and not ~~in~~ contact ~~with~~ the ground plane. Any ~~except where the~~ plug shield contacts should mate ~~to~~with the breakout jack shield. ~~It is recommended that t~~The cable between the transmitter and the cable clamp should 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.

The differential-mode and common-mode voltage outputs of the balun and breakout fixture should meet the limits shown in Table 113A-2~~1~~ over the frequency range ~~8~~1~~0~~ MHz to 2 000 MHz for each cable pair.

Table 113A-2~~1~~ - Common- and differential-mode output voltage~~s~~

Frequency (f)	Common-mode voltage	Differential-mode voltage
1 MHz ~~80~~- 30~~250~~ MHz	<0.1+0.97(f/30) Vpp~~<1.07 – 0.6 (f-80)/170 Vpp~~	<2.4 + 19.68 (f/30) mVpp~~<22 mVpp (-29 dBm)~~
30 ~~250~~MHz ~~-2~~ - 080 ~~00~~ MHz	<1.07 Vpp~~<470mVpp (-2.6dBm)~~	<22mVpp
80 MHz - 250 MHz	<1.07 – 0.6 (f-80)/170 Vpp	<22 mVpp
250 MHz - 2 000 MHz	<470mVpp (-2.6dBm)	<22mVpp (-29 dBm)

Comment [CPR6]: [Commenter's input: Is there a Note 1?] Ad hoc discussion confirmed that no, there is no Note 1, but just "Note". Suggest changing "Note" in the text to "Note 1"

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Comment [CPR7]: Reverted to the 20MHz defined in Annex 40B for future use with 803.bz. 80MHz for P8023bq was selected since it was the minimum frequency being tested; with a lower "generic" range of 1MHz we can go back to 20MHz.

Comment [CPR8]: Suggest something like "consistent with good RF measurement practices." That seems to be the winner. Or just state "direct contact".

After the setup has been validated, the clamp, cabling, and choke positions should remain unchanged when performing any receiver tests.

NOTE 1 - ~~Prior to conducting the validation test~~~~As per 113A.1~~ Prior to making validation measurements or performing the test described in 113A.4, 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~~ output should be adjusted to ~~6dBm~~ the specified signal power (for example, 6 dBm for 40GBASE-T) at 2~~8~~0 MHz on the signal sensor. When the frequency is varied from 1 ~~80~~MHz to 2 000 MHz, 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.

113A.~~2~~ 4 ~~25/40G Test~~Test Setup ~~Setup~~

Cabling up to the maximum specified length that meets the link segment specification for the PHY under test (for example, Clause 113.7 for 40GBASE-T), is connected between two such PHYs and inserted into the cable clamp. The cable should be terminated on each end with an MDI connector plug specified for the MDI of the PHY under test (for example, Clause 113.8.1 for 40GBASE-T).

~~Up to 30 meters of cabling 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 breakout fixture and balun are replaced by the transmitter/receiver under test, with the system port positioned at the original location of the breakout. The clamp ~~, cabling, and choke positioning should be the same as the 113A.2 Validation, and the Transmitter/receiver under test should be positioned where the breakout was originally. The clamp~~ should be located a distance of ~20 cm from the receiver port.

~~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~~As described in~~with~~ the validation setup, the cable clamp and ~~40GBASE-T~~t~~T~~ransmitter/ receiver under test should be placed on a common ground plane and the system ground ~~of the receiver~~ should be in direct ~~low inductance~~ 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 1~~80~~ MHz to 2 000 MHz or other cable-clamp-coupled impairment as specified. The output of the signal generator (as ~~is~~ adjusted in 113A.3 Note 1) is applied to the clamp input ~~for a signal power not to exceed 6 dBm at the signal sensor~~ to simulate the specified impairment (for example, an external electromagnetic field of approximately 3 V/m).

~~The signal influence over data received from the far end transmitter is assessed by the manufacturer.~~

Comment [CPR9]: Ad hoc discussion suggested including a comment in the previous section noting that the same configuration should be used for both validation and configuration.

Comment [CPR10]: Original commenter's input: It's position here makes it unclear if this correction applies above or below or both. Also, earlier submissions indicated doing the correction based on measurement with the cabling and choke. Also power correction is called into question based on Moffitt initial chamber comparison submission. All this needs to be resolved.

Clarifying comments after the ad hoc:

1. Where does the correction apply?
   - This note follows the original positioning and text of Annex 40B. Note 1 has been interpreted as verifying the response of the unloaded/no cable clamp before performing the validation check. Therefore, the note applies to the validation procedure.
   - The normative specification states that the source power is calibrated so that the signal power measured at the output of the clamp does not exceed a specified maximum; this is in fact the calibration that is performed; i.e. measure the response with no cable inserted.
   - The suggested reference to 113A.1 seems unclear; the proposed text is intended to better indicate that this is to be performed prior to testing as well.

2. Correction with cable and chokes?
   - Earlier P802.3bq and recent P802.3bz contributions do show that the overall system response is different when calibrated with/without the cable inserted in the clamp. However, given that the intent of the test is to align with regulatory testing, note that the EMI chamber field calibration does not attempt to assure a constant coupled signal level - the cabling/interconnect/grounding/shielding elements respond to a field calibrated for a specific power level at fixed points in space. Hence the similar approach of calibrating to a fixed "no cable" injected source power.

3. Appropriate source power – Agree that further study is appropriate, but we do need to complete ...

Comment [CPR11]: Restored original tile for general usage.

Comment [CPR12]: [Commenters input: adjusted needs a clear explanation] . The ad hoc needed clarification on this comment, but I believe that this refers to the "above or below". General interpretation is that adjusted is w/o the cable; perhaps the suggested text is better. For further discussion

Comment [CPR13]: This add is covered in 113.5.4.3 with text that aligns with EMI operational requirements; striking to allow flexibility for different operational or pass/fail requirements in other clauses.

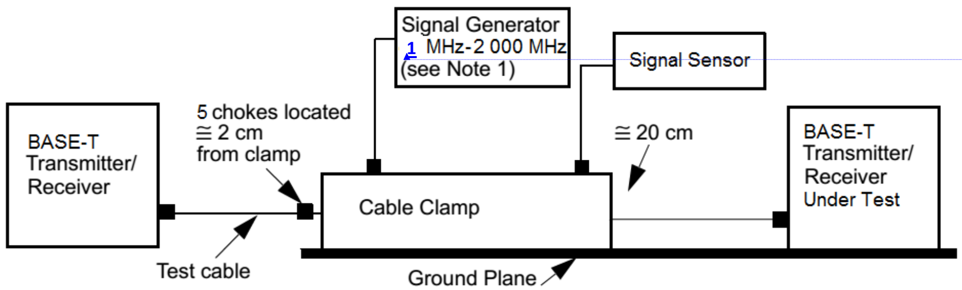

Figure 113A-4 - Cable clamp test configuration

113A.5 2.5/5/10G Setup Validation and Test

For testing the sensitivity of 2.5/5/10GBase-T receivers, Annex 40B may be used at extended frequencies as described in 55.5.4.3 Common-mode noise rejection. Alternatively the clamp described in 113A.1 may also be used, but the Setup Validation and testing is done with suitable unshielded cabling, and currents are induced directly onto the cabling pairs.

[Commenters note: How different will the clamps behave and what parameters must be outlined?]

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Comment [CPR14]: [Commenter's input: Is there a Note 1?] Similar to previous comment.

Comment [CPR15]: Suggest removing so that other MultiGBASE-T PHYs can be accommodated by describing source power, impairment types and frequencies, cabling and