Compatibility between NRZ EDC and Optical Mode Filtering Proposals

Presented by Michael Lawton, Agilent Technologies
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Contributions and support from:

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Summary

- **Presentation in response to an action given by David Law at the May meeting**

    - **"Can we combine Optical Mode filtering and NRZ EDC and develop a single spec, if not why not?"**

- **Compared TP2 and TP3 tables for NRZ EDC and Mode filtering approaches**
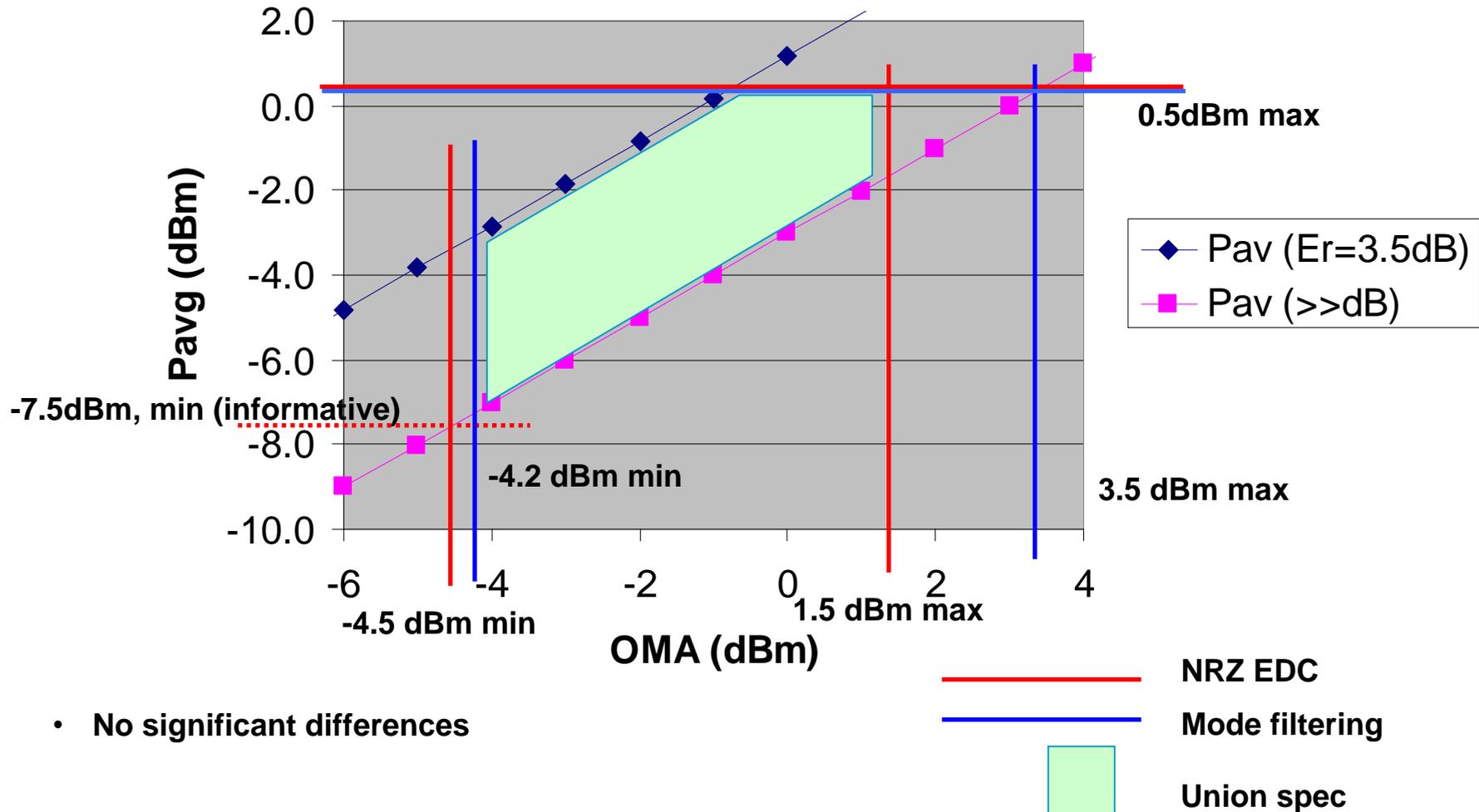
Transmitter Parameter Differences (TP2)

Description	Type	MODE FILTERING*	NRZ EDC	Union spec?	Unit
RMS spectral width	max	0.5	5	Yes but limits scope of implementation	nm
Average launch power (informative)	min	-7.2	-7.5	Yes	dBm
Optical modulation amplitude	max	3.5	1.5	Yes	dBm
Optical modulation amplitude	min	-4.2	-4.5	Yes	dBm
Transmitter eye mask definition {X1, X2, X3, Y1, Y2, Y3}		?	{0.25, 0.40, 0.25, 0.28, 0.4} relaxed tbd		
Encircled flux test 50μm patch cord		NA	>86% in 19μm radius <30% in 4.5μm radius	**NO test criteria mutually exclusive with Mode filtering approach**	
Encircled flux test 62.5μm patch cord		NA	>86% in 24μm radius <30% in 4.5μm radius	**NO test criteria mutually exclusive with Mode filtering approach**	
Launch beam conformance		0.5		**No test criteria mutually exclusive with NRZ EDC approach**	dB

- **spectral width limits scope of implementation**

- **Launch requirements are mutually exclusive**

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* taken from ereifej_1_0504.pdf

10GBASE-LRM Transmitter Power Window

10GBASE-LRM Launch Powers

- **No significant differences**

Link Power Budget (informative)

Parameter	Mode Filtering*	NRZ EDC	Comments	Units
Connector losses (by fiber type)	1	2.0	ok (lower loss for mode filtering)	dB
Fiber attenuation (220m)	0.5	0.4	ok	dB
Mode selective loss (includes source induced modal noise)	6	0	need more detail on modal noise contribution	
Modal noise penalty	??	0.5		dB
RIN penalty	??	0.4	similar to NRZ?	dB
Rx Dynamic Adaptation Penalty	?	0.5	need more detail on mode filtering Rx adaptation	dB
Consequent Penalty		0.2	unallocated = 0.5dB	dB
EDC insertion penalty	1	4.5+1	need more detail on mode filtering EDC penalty	
unallocated	0.5			
Total	**9dB**	**9.5**		**dB**

- **Whilst the totals are similar the breakdowns are significantly different – this represents a challenge for Rx testing**

- **Mode filtering proposal needs more information in support of modal noise and EDC penalty**

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* taken from ereifej_1_0504.pdf

Interpreting the EDC Link Budget (OMA)

+1.5dBm

Tx power window

-4.5dBm

additional EDC implementation penalty

TP3 compliance test category:-

Rx level for stressed receiver sensitivity

connector losses = 2dB

Fiber attenuation = 0.4dB

loss

Rx dynamic adaptation penalty= 0.5dB

-7.6dBm

consequent penalty = 0.2dB

emulated by loss

Modal noise = 0.5dB

added noise

RIN = 0.4dB

matched filter bound sens equiv to –13.1 dBm with LR filter

Ideal EDC noise enhancement penalty = 4.5dB

added dispersion

EDC implementation penalty = 1.0dB

-14.0dBm

Not a spec item as AGC performance not required

Required only for feasibility/design work

Interpreting the Mode Filtering Link Budget (OMA)

+3.5dBm

Tx power window

-4.2dBm

TP3 Compliance test category:-

excess connector loss in channel = 1dB

channel loss

Fiber attenuation = 0.5dB

unallocated = 0.5 dB

-6.2dBm

Mode selective loss = 6dB
includes modal noise

receiver loss

Rx level for stressed Rx sensitivity @ TP3

EDC insertion penalty = 1.0dB

added dispersion

-13.2 dBm

Rx level for link with no dispersion
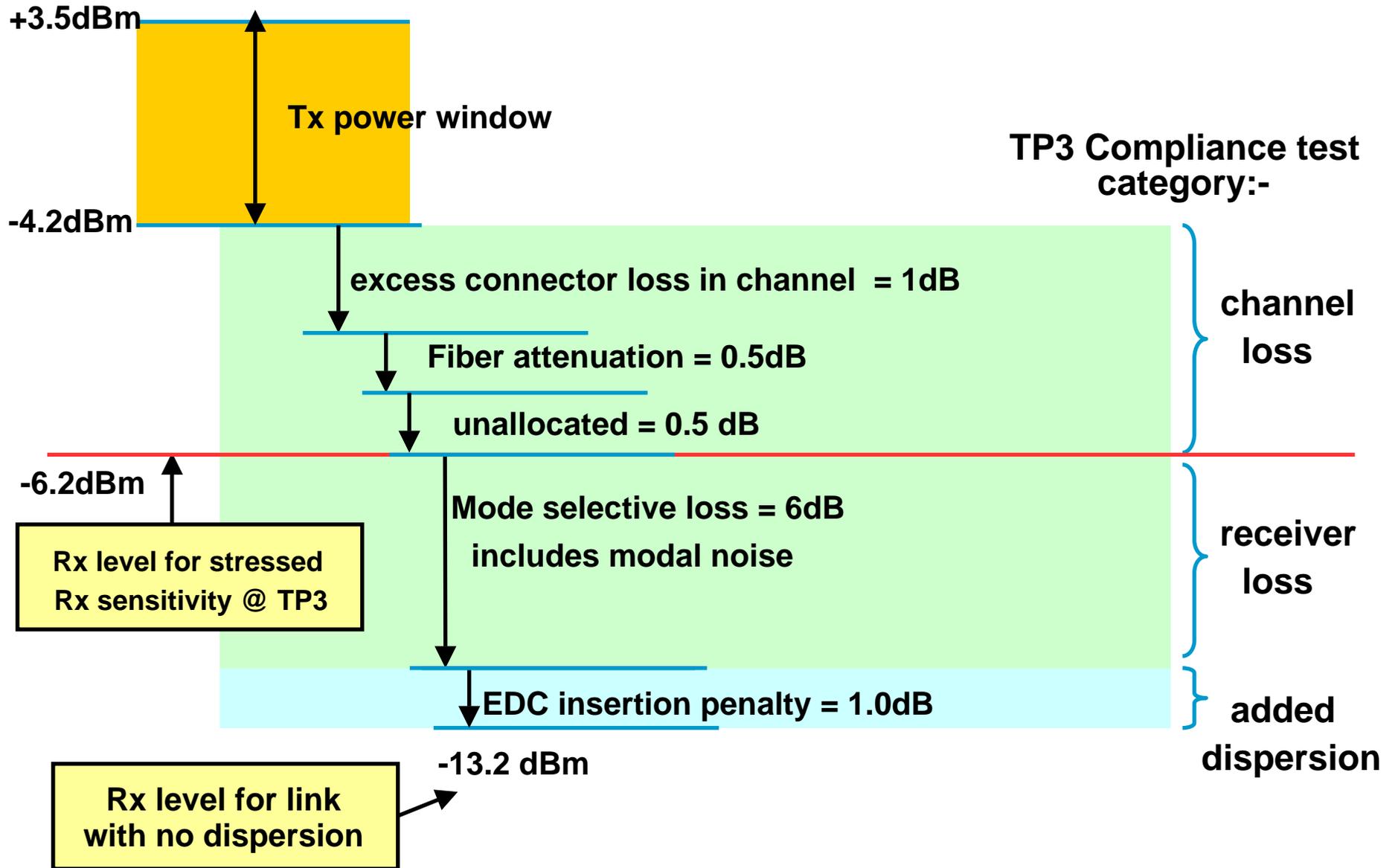
TP3 Conformance Testing 10GBASE-LR …
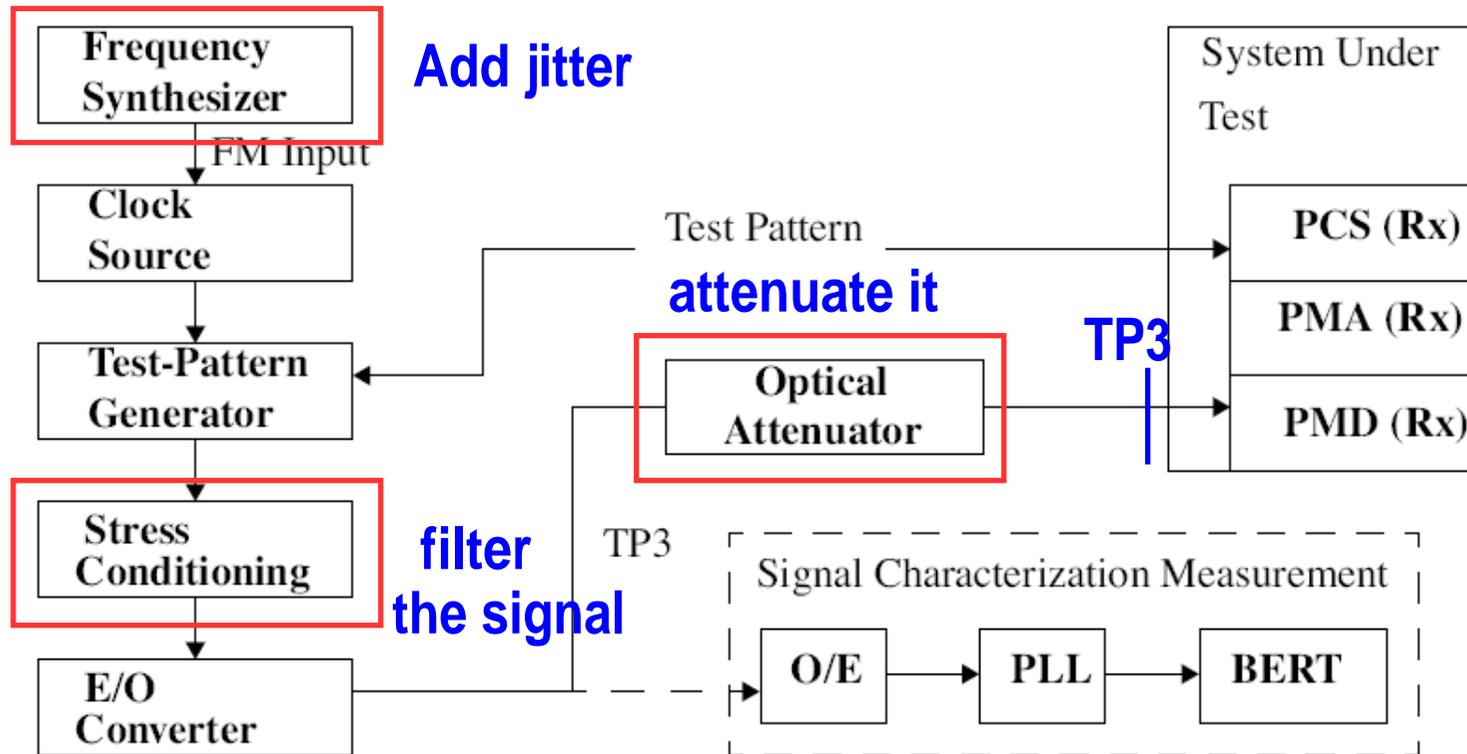
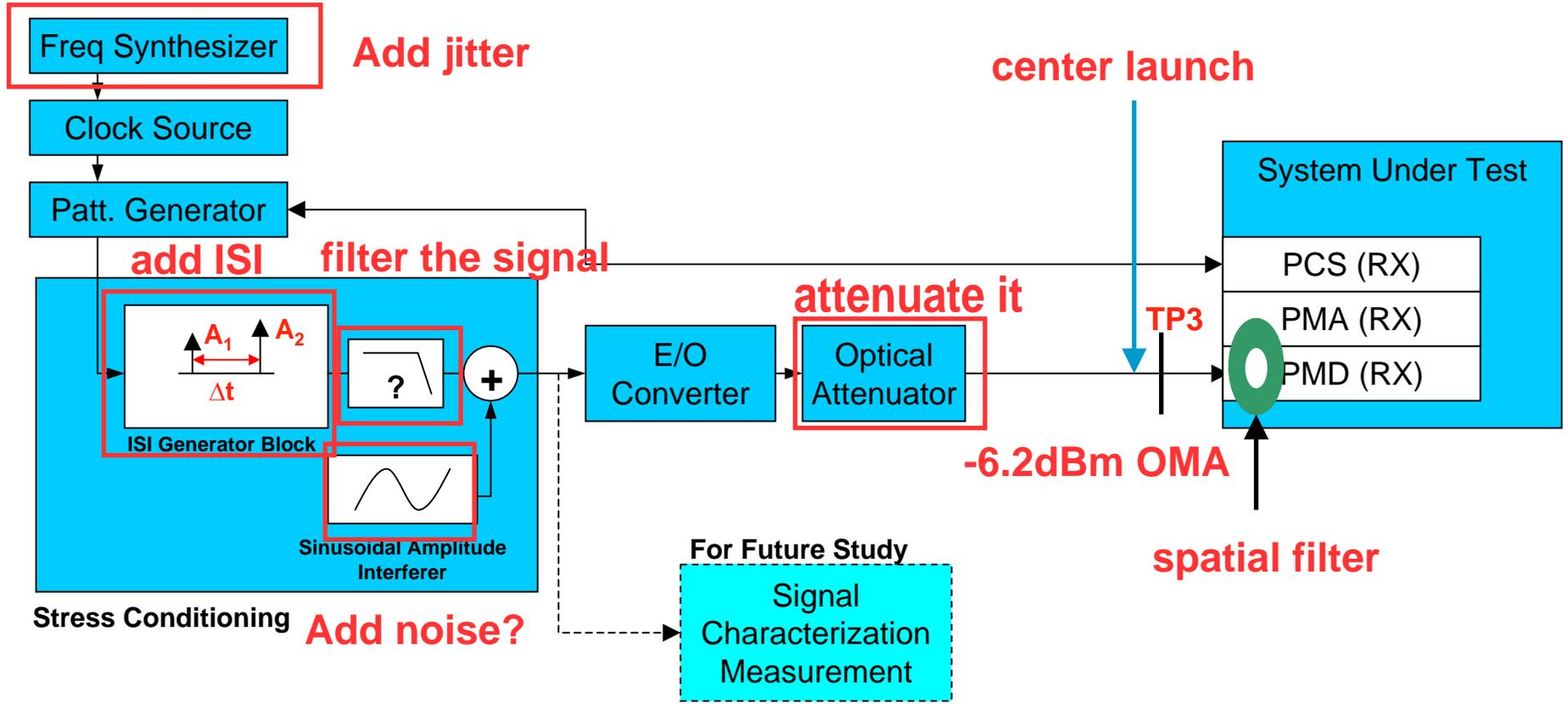Figure 53–10—Receive jitter test block diagram

- **Diagram taken from 802.3ae**

TP3 Conformance Testing … NRZ EDC
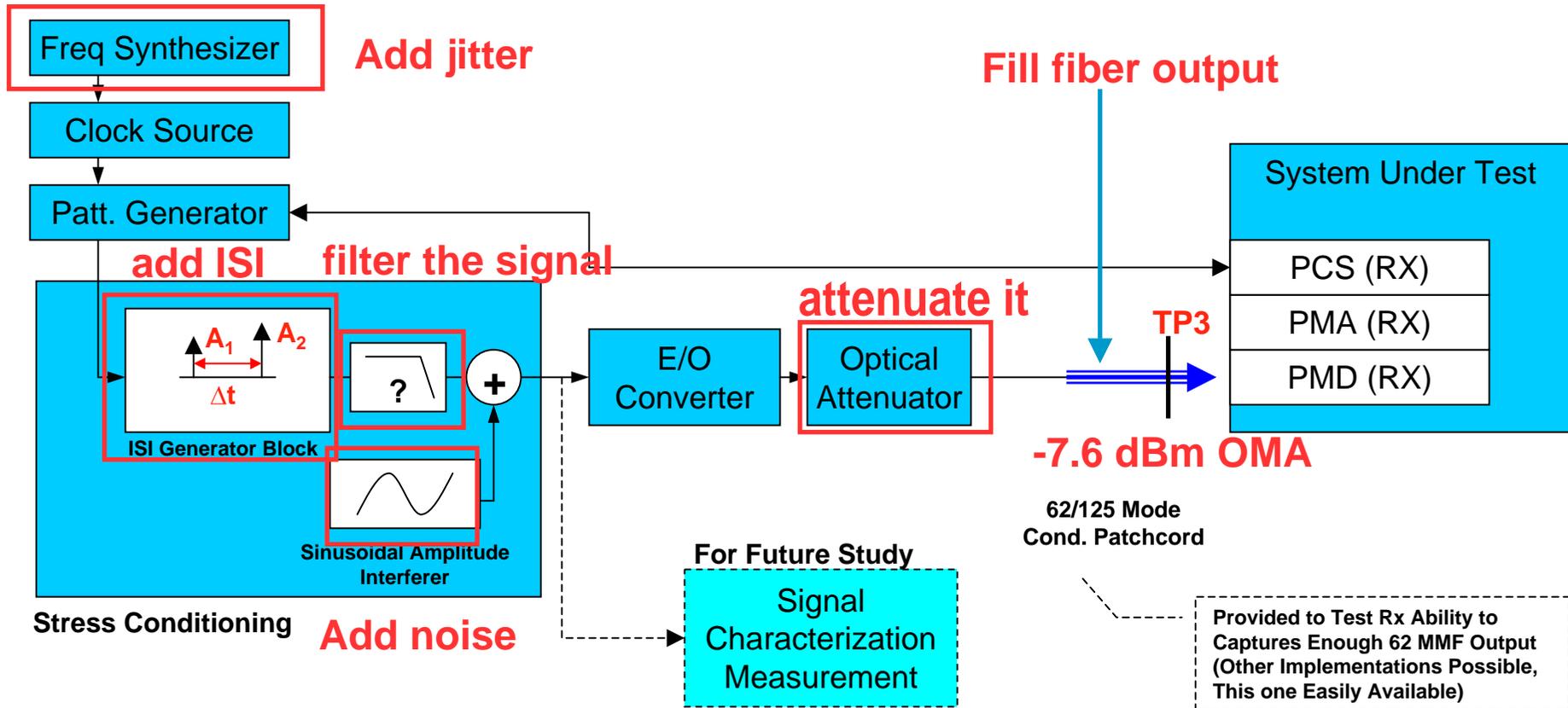
- **Diagram taken from presentation to be given by Lew Aronson**
- **Approach is similar to 10GBASE-LR with additional stress terms:-**
  - **ISI, Modal noise, RIN**

TP3 Conformance Testing … Mode Filtering + EDC

Freq Synthesizer

Add jitter

center launch

Clock Source

Patt. Generator

add ISI   **filter the signal**

System Under Test

PCS (RX)

attenuate it

TP3

PMA (RX)

A_1 A_2

Δt

?

+

E/O Converter

Optical Attenuator

PMD (RX)

ISI Generator Block

-6.2dBm OMA

Sinusoidal Amplitude Interferer

spatial filter

Stress Conditioning   **Add noise?**

For Future Study

Signal Characterization Measurement

- **This test would require different parameters for ISI, noise and attenuation**

- **Test would also need to be done without a center launch patchcord**

Receiver parameters (TP3)

Parameter	Type	Mode filtering*	NRZ EDC	Union spec	Units
Received OMA	max	NA	+1.5		dBm
Average receive power (informative)	min	-14.7 (-8.7)**	-9.9	possible if spatial filter is internal to Rx and wide area detector used.	dBm
Receiver sensitivity in OMA (informative)	max	-13.2 (-7.2)**	NA		dBm
Receiver sensitivity with ISI only in OMA	max		???		dBm
(Static) Stressed receiver sensitivity in OMA (with ISI and sinusoidal jitter and noise applied)	max	-6.2?	-7.6 (TBC)	**very different tests**	dBm
3dB electrical bandwidth	max	7.8	NA		GHz

** numbers in brackets denote the power figure as measured by a wide area detector

Is there a single specification …

- No:

  - Tx: Two proposals have mutually exclusive launch requirements at TP2

    Requires a restricted spec to meet spectral width requirements

  - Rx: Requires two completely different specification tables

- Is any level of inter-operability achievable?

  - In theory a limited level of interoperability could be achieved by defining 2 transmitters (with different patchcords for their respective launch requirements) and 2 receivers. These could then be used in appropriate combinations to provide working links

    - see next slide for permutations

    - This requires access to both ends of the link and is stretching the limits of practicality

    - Not robust enough to be considered within a standard

- **WHILST THIS WOULD BE FEASIBLE IT DOES NOT REPESENT AN OPTIMAL SOLUTION AND HENCE NOT ONE THE STANDARDS GROUP SHOULD FOLLOW**

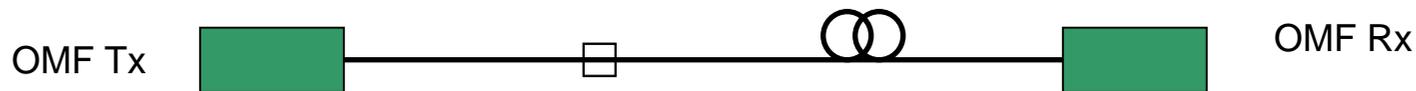# Compatibility can be achieved if launch conditioning is external to the module …

EDC Tx ▮━━━━━━▯━━━━◯◯━━━━▮ EDC Rx

a) EDC based Tx and Rx
 Depending on channel will work with or without patch cord. Performance will be better with a patchcord

EDC Tx ▮━━━━━▯━━━━◯◯━━━━▮ OMF Rx
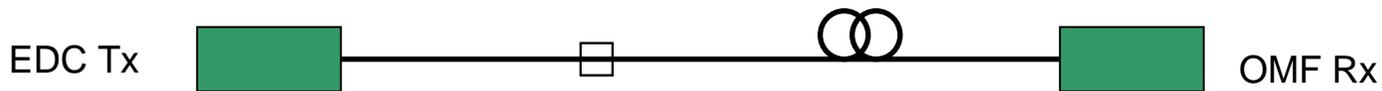
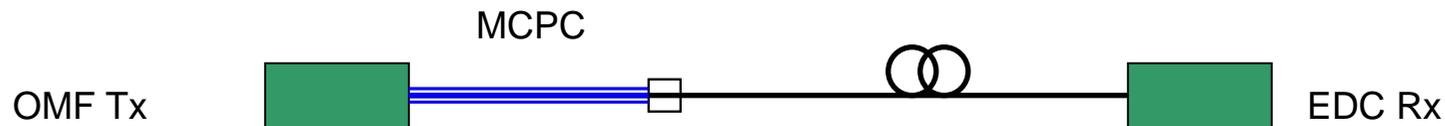**b) EDC based Tx and OMF based Rx**
Will not work with OFL patch cord. Will work without it, assuming center launch is specified.

OMF Rx

OMF Tx ▮━━━━━▯━━━━◯◯━━━━▮

c) OMF based Tx and OMF based Rx
 Will not work with OFL patch cord. Will work without it.

MCPC

OMF Tx ▮━━━━━━▯━━━━◯◯━━━━▮ EDC Rx

d) OMF based Tx and EDC based Rx
Depending on channel will work with or without patch cord. Performance will be better with patchcord

Conclusions

- **No union spec is possible. A combined specification would require separate TP2, TP3 tables for both Tx and Rx**

- **Some level of interoperability could be supported if the launch was made external to the module**

  - **specification would have reduced scope of implementation compared with NRZ EDC**

- **Users in the field would need to "experiment" with and without patchcords to support interoperability**

- **Recommend the group do not attempt to develop a union spec which combines mode filtering and NRZ EDC**