Eye mask for 100 Mb/s

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Problem statement

- 125 MBd on single mode fibre using FDDI line code (4B/5B with NRZI)
- FDDI uses “pulse mask” which is not suitable for laser based links
- Need to define new eye mask

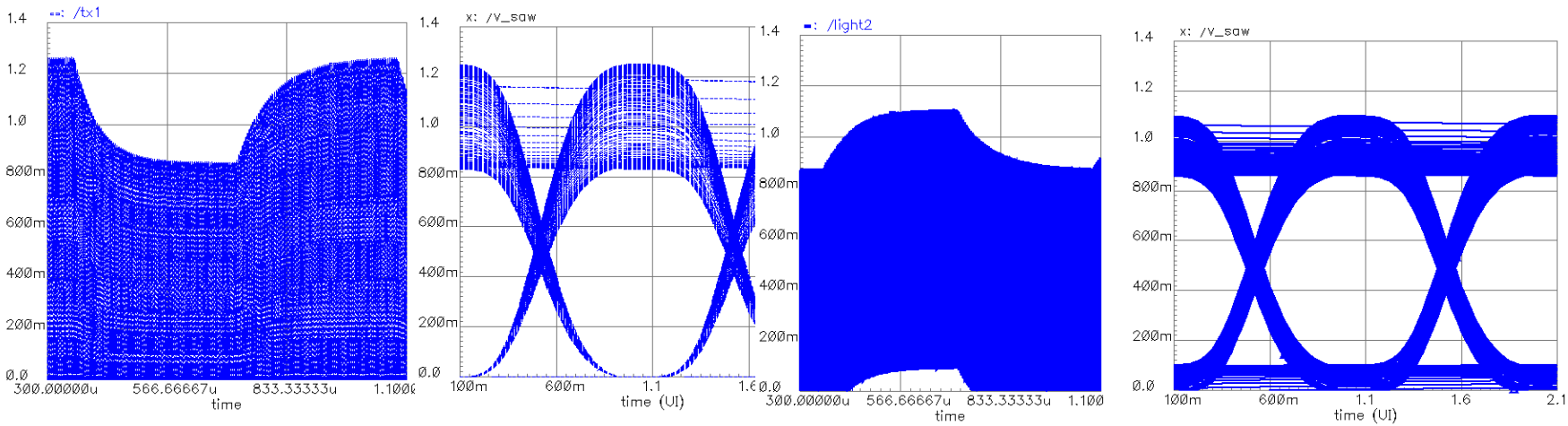
Problems

- FDDI line code allows 40% or 60% mark density over thousands of bits
  - Depending in implementation, will be considerable (but bounded) baseline wander (BLW) and/or AM effect
- EMI unfriendly with a very simple idle pattern (few spectral lines)

… and advantages

- Low bit rate, single mode fibre
  - Very little distortion in fibre
  - Silicon is adequately faster than signal
  - Can sacrifice some sensitivity for simplicity (low cost, low heat)

Example transmitter responses



- Depending transmitter implementation,
  - some 1s are lowered by 1/6 of eye height
  - some ones are raised by 1/4 of eye height
  - some zeroes are raised by 1/10 of eye height
  - Extra pulse shrinkage jitter is created
- These are simulations of a very clean signal

Approach to finding eye mask 1/3

- Be tolerant of reasonable alternative transmitter implementations
- Test with “worst case” pattern
  - No need for the standard to test the best case
    - Just need to know that “typical” is adequately better than “worst”
- Tolerate the baseline wander
  - Spend some sensitivity to allow a shallow mask
- Tolerate the resultant pulse shrinkage jitter
  - can be mitigated with fast transmitters and receivers but may not need to

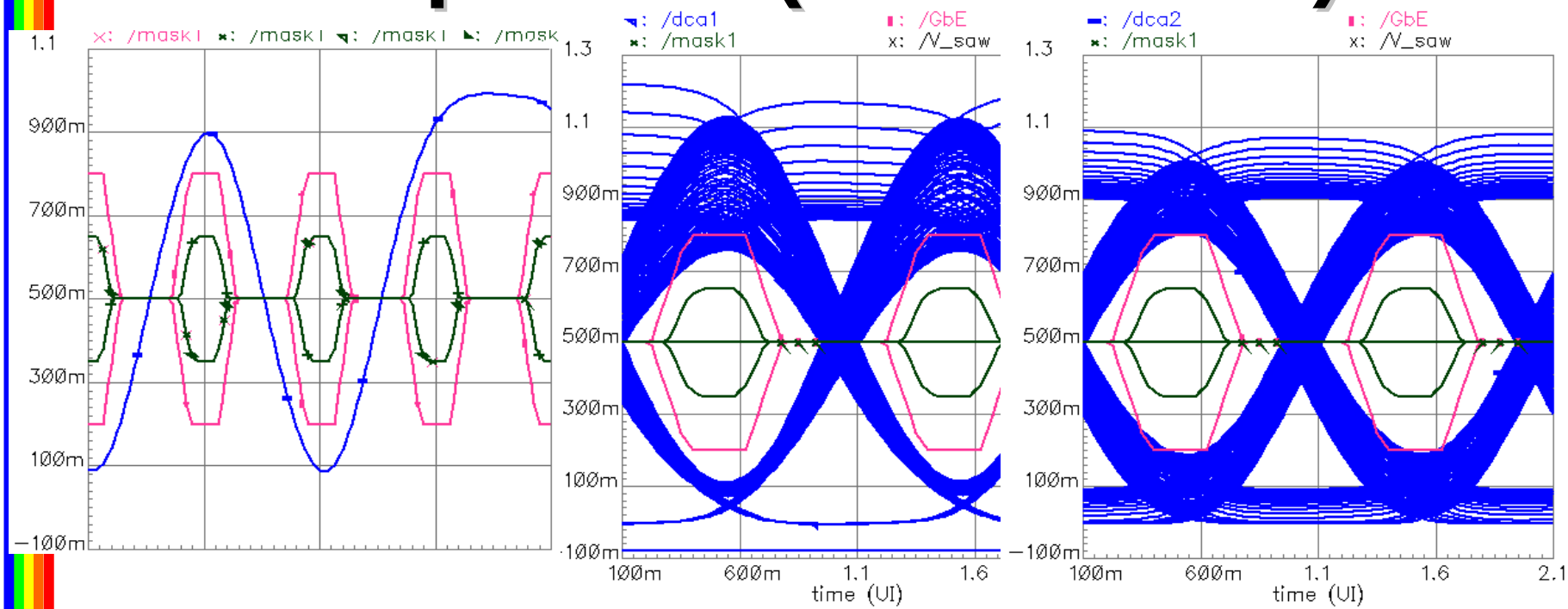
Approach to finding eye mask 2/3

- Do not attempt to specify jitter or risetime separately
  - specify their combination via eye mask
- Make no attempt to define or enforce a “transmitter time constant” (of BLW)
  - No need to, receiver should cope with any time constant that allows a mask pass
- 10 pointed mask may give reduced measurement error vs. 6 pointed mask
  - Also represents the ellipse shape of CDR decision locus

Approach to finding eye mask 3/3

- Allow overshoot per modern masks for cost effective laser links plus allowance for baseline wander
- Mask to be measured with existing test equipment: DC coupled digital communications analyser
- Instead of 125*3/4 = 94 MHz measurement filter, appropriate for balanced line code, use OC-3 filter (117 MHz) to recognise likely receiver speed
  - Also benefit of cost and convenience

Example slower transmitter responses (simulations)



Left: Slow waveform without baseline wander

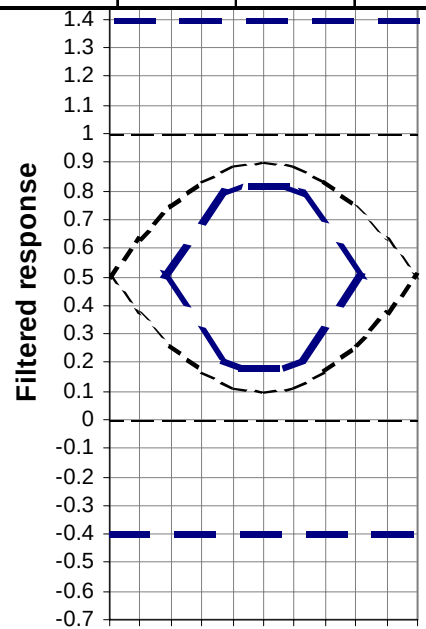
Right: Two different “implementations” in simulation with test pattern, same HF filters

Red: Gigabit Ethernet mask Green: proposed mask

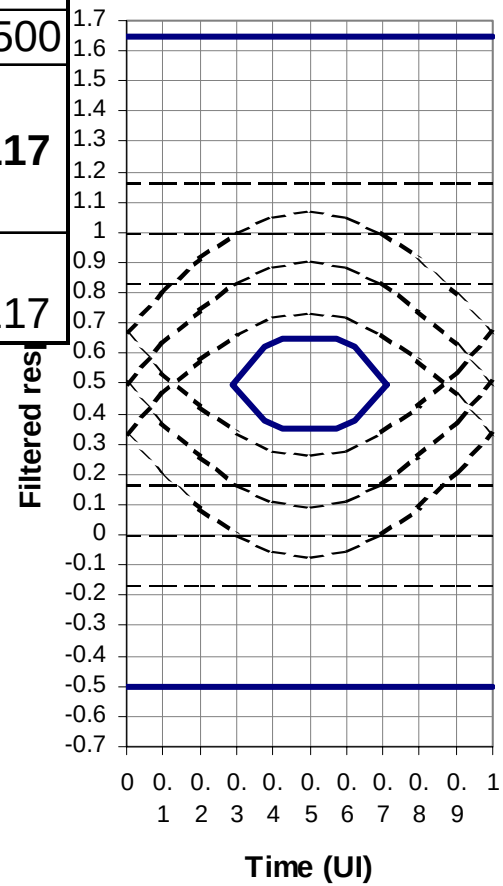
Proposed mask and comparison with other standards

Line rate		X1	X2	X3	Y1	Y2	Y3	Y4	Filter
Units	**MBd**	**UI**	**UI**	**UI**					**MHz**
OC-3	155	0.15	0.35	0.35	0.2	0.2	0.2	0.2	117
GbE	1250	0.22	0.38	0.375	0.2	0.2	0.3	0.3	938
10GbE	~10,000	0.25	0.4	0.45	0.25	0.28	0.4	0.4	7500
Proposed 100M with worst pattern	**125**	**0.29**	**0.375**	**0.425**	**0.35**	**0.38**	**0.5**	**0.65**	**117**
Implied for easy pattern	125	0.18	0.38	0.425	0.18	0.21	0.40	0.40	117

- Left: for easy pattern (no baseline wander)
- Right: for test pattern ("worst")



Proposed eye mask for 100M worst pattern



To do

- Noticing how the pattern adds deterministic jitter,
  - Develop TP1 and TP4 jitter specs accordingly
- Check that real receivers can cope
  1. Optical transceiver
  2. Silicon SERDES chip

Conclusion

- New mask proposed specifically for this line code over single mode fibre
- Proposed mask is optimised for cost and simplicity, allows good thermal and EMI properties
- To be used with a “worst case” pattern and standard test equipment