1394b (PHYBOYS) Task Group - 3rd March 1997

Design homework for 1394 800 Mbps PHY

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- AC connections in a mixed system
- Beta-mode startup
  - synchronisation
- Power saving
- Beta mode power-on start-up
  - fibre-ready specification

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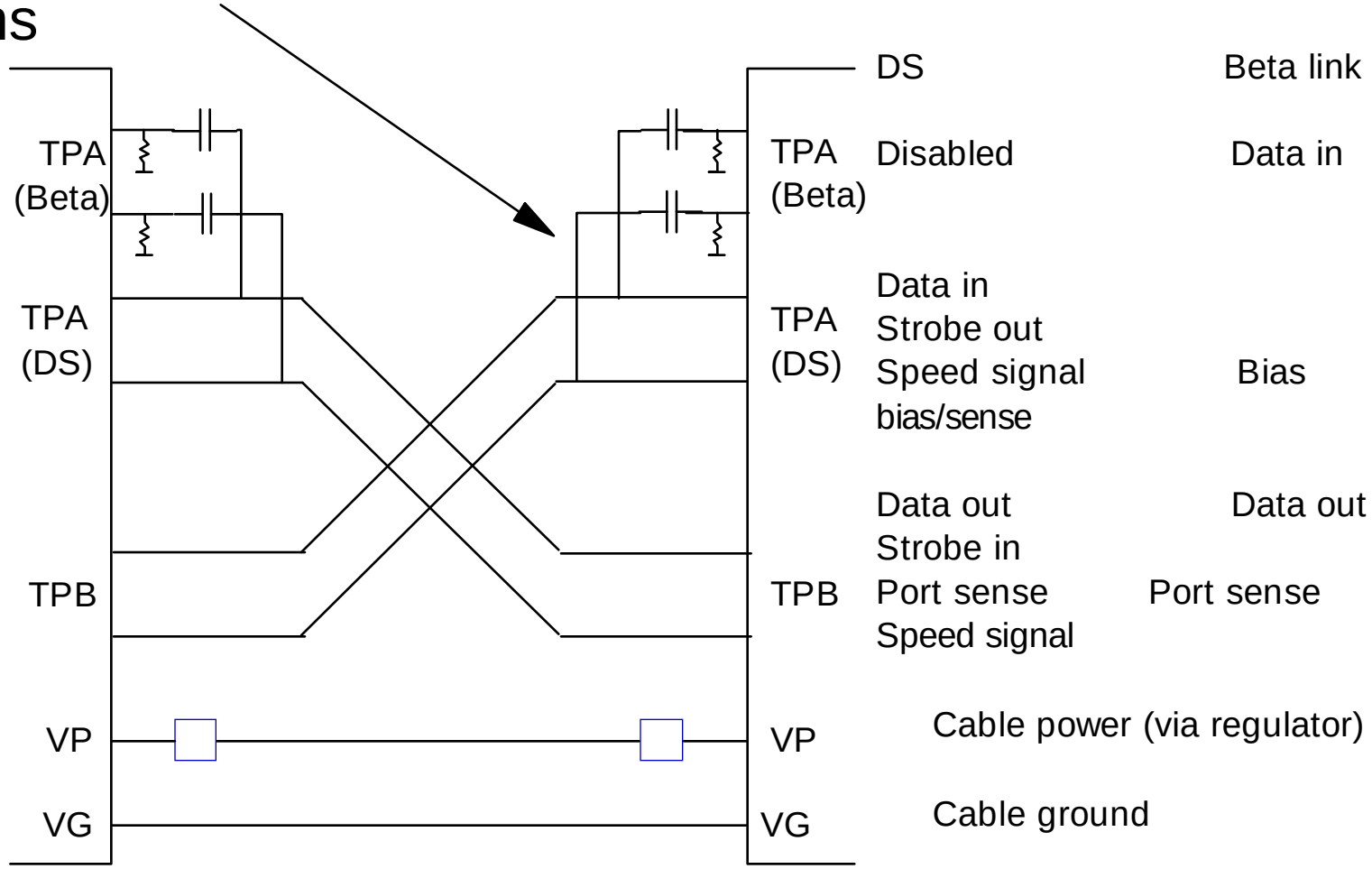
AC Connections and Functions

- Propose to call the high speed link a "Beta link" (at least, for the purposes of this presentation)
  - and the way of working "Beta mode"
  - would have proposed B-link - but this is already taken
- Last meeting had a general agreement for Beta mode
  - Continuous transmission with no line reversal
  - Transmit on TPB, receive on TPA
  - At least allow AC coupling (implies separate pins for DS mode and Beta mode, for either TPA, or TPB, or both)
- Splitting the connection can lead to impedance mis-matches
  - causes signal reflections and impacts signal integrity
- We cannot find a perfect solution
  - look at the + and - of various possibilities
  - want best integrity for the highest speed

AC connections and pin functions

This is how we left a typical configuration last time

Our concern: the TPA connection can have problems with reflections

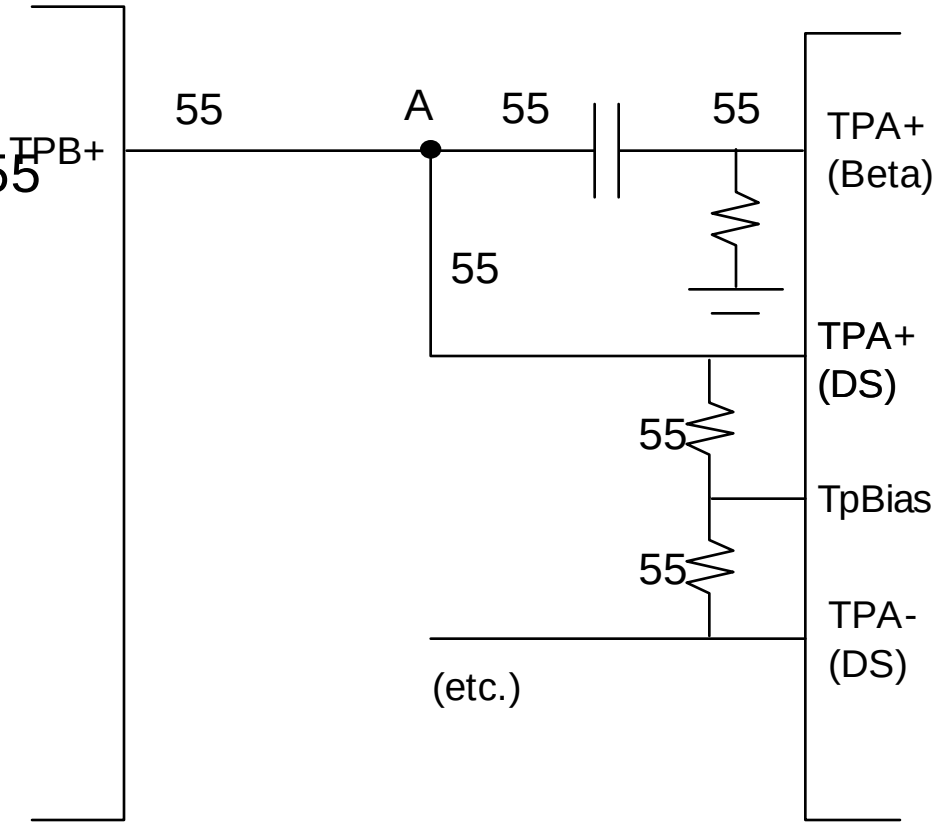


Modes of use

- We need to find a method of connection which will work for both DS and Beta mode
- The concerns we have relate to each individual transmission line
  - TPA+ to TPB+ and TPA- to TPB-, in each direction
  - differential signalling does not help these problems
  - the following diagrams look at just one connection in one direction
- Four cases to consider - in order of priority
  - Beta mode transmission from TPB to TPA (Beta)
  - DS mode transmission from TPB to TPA
  - DS mode transmission from TPA to TPB
  - Effect on TpBias for speed signalling
- Four configurations are presented
  - Three use separate TPA pins for AC coupled connections
  - We also looked at using separate TPB pins instead, but this did not help (see configuration 4)

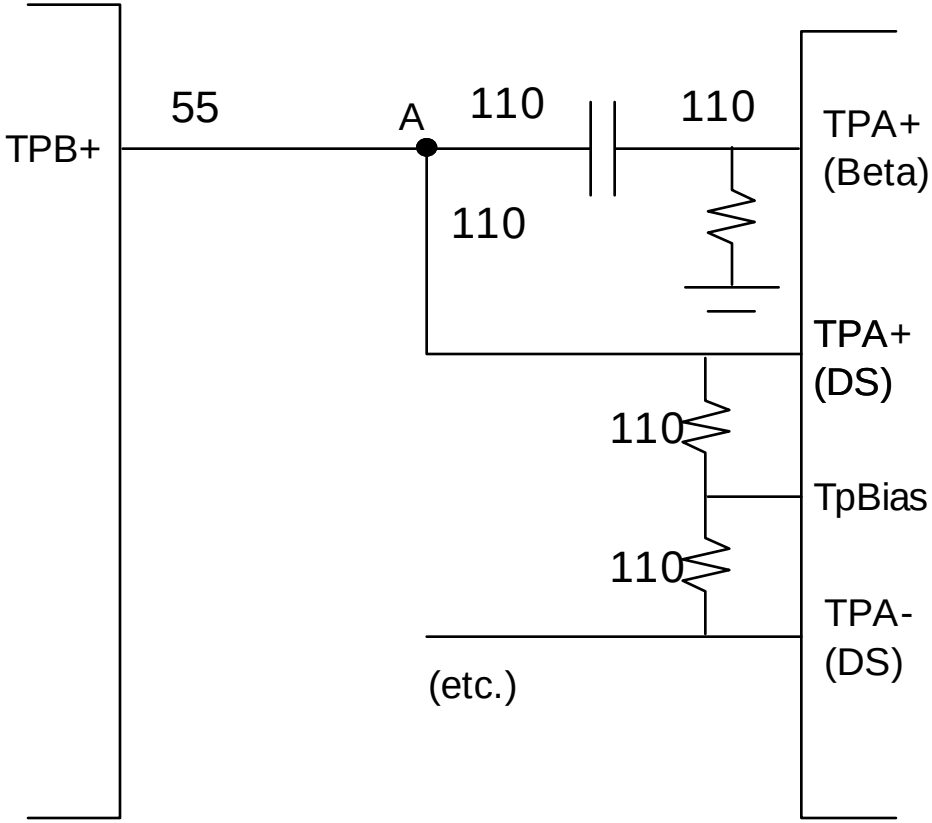
Configuration 1

- Configuration 1 - use 55 Ohm lines throughout, terminate all connections at 55 Ohms when active, high impedance otherwise
  - Beta mode from TPB to TPA(Beta)
    - × mismatched - transmission line effectively becomes 27 Ohms at point A, reflections will cause loss of signal integrity
  - DS mode from TPB to TPA
    - × mismatched - likewise
  - DS mode from TPA to TPB
    - × mismatched - likewise
  - TpBias
    - ✓ OK



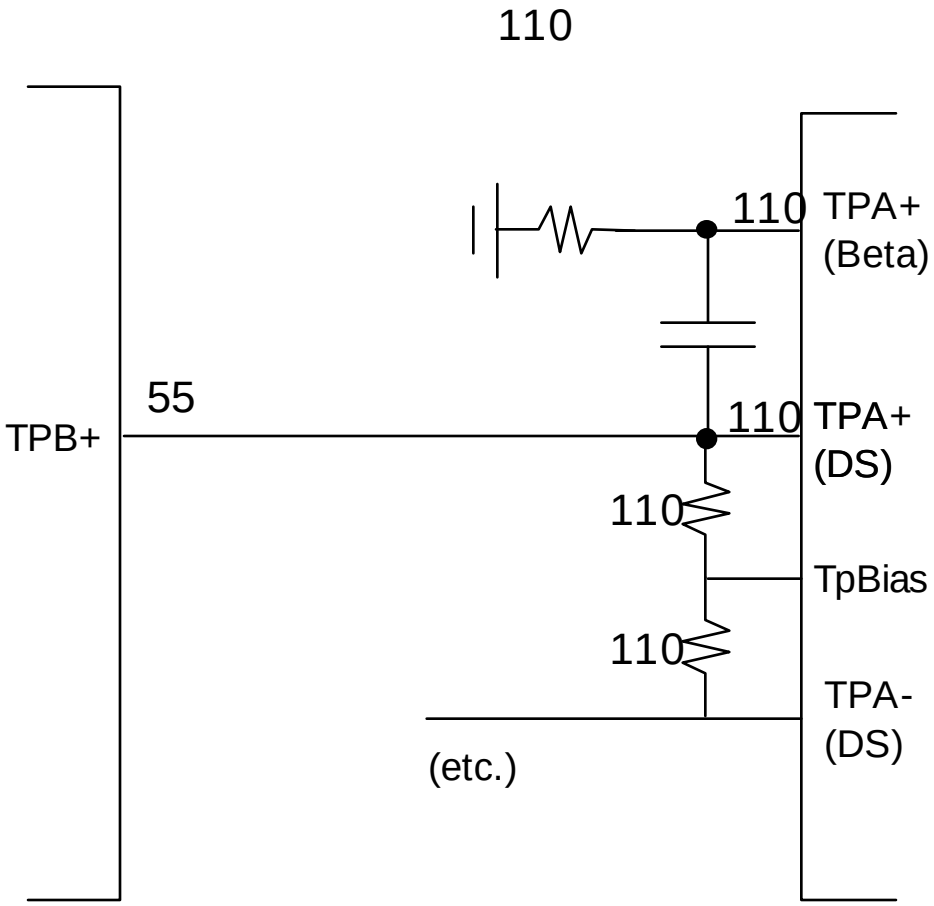
Configuration 2

- Configuration 2 - use 110 Ohm lines for each track "after" the split for DS and Beta, terminate TPA and TPB to 110 Ohms when active, high impedance otherwise
  - Beta from TPB to TPA(Beta)
    - ✓ matched
  - DS from TPB to TPA
    - ✓ matched
  - DS from TPA to TPB
    - × not matched - 110 Ohms meets 37 Ohms at point A
  - TpBias
    - × sees 110 Ohms - doubles the speed signalling voltage drop when TPB sources (negative) current - won't work for S400 speed signalling



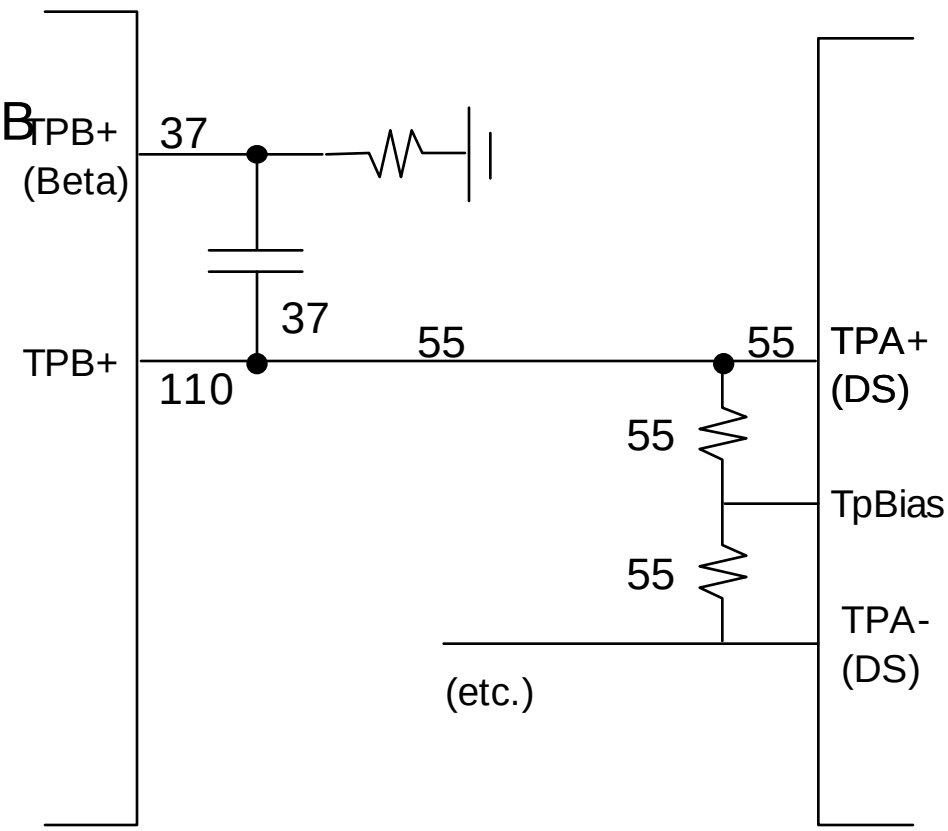
Configuration 3

- Simply re-draw configuration 2 to minimise the stub lengths
- Configuration 3 - use 110 Ohm lines for each track "after" the split for DS and Beta, terminate TPA and TPB to 110 Ohms when active, high impedance otherwise
  - Beta from TPB to TPA(Beta)
    - ✓ matched
  - DS from TPB to TPA
    - ✓ matched
  - DS from TPA to TPB
    - not matched, but length of stub minimised (but don't forget the bond wire)
  - TpBias
    - × sees 110 Ohms - doubles the speed signalling voltage drop when TPB sources (negative) current - won't work for S400 speed signalling
    - ✓ use speed detection instead



Configuration 4

- Configuration 4 - use TPB+ Beta for transmission with isolating capacitor driving into 37 Ohms; use 110 Ohm lines for TPB "after" the split for DS and Beta, terminate TPA to 110 Ohms and TPB to 55 Ohms when active, high impedance otherwise
  - Beta from TPB (Beta) to TPA
    - ✓ matched
  - DS from TPB to TPA
    - × gross mis-match (110 Ohms meets 21 Ohms)
  - DS from TPA to TPB
    - × not matched (55 Ohms meets 27 Ohms)
  - TpBias
    - ✓ OK for speed signalling
- Does nothing to remove noise picked up on the cable
- Ruled out - too complex



Chip and board layout issues

- Chip issues
  - We need TPA(Beta)+ and TPA(Beta)- on adjacent pins
  - We need TPA+ and TPA- on adjacent pins
  - We need TPB+ and TPB- on adjacent pins
- Board issues
  - There needs to be a capacitor between TPA(Beta)+ and TPA+, with minimum track length (pref. 0) to TPA+
  - There needs to be a capacitor between TPA(Beta)- and TPA-, with minimum track length (pref. 0) to TPA-
  - There are various other external components to be included with minimum track lengths
  - Both 55 Ohm and 110 Ohm stripline has to be implemented, with very careful design to the transition points
- This looks like a challenge
  - What's the view of the board designers?

AC coupling conclusions

- AC coupling is highly desirable
  - previous inputs
  - common wisdom for gigabaud transmission over cables
- AC coupling is possible
  - requires a separate pad for each connection (two extra pads)
- DS link integrity may be affected in the best compromise that we have identified
  - minimised by careful board design
- Board design challenges have been identified and need further study
- Common mode speed signalling for DS transmission will not work
  - can use speed detection instead

Beta mode start up - 1

- After reset, do Tree-ID and Self-ID as now
- The last self-ID packet from a child node to a parent node is the child's own self-ID packet
  - A parent can therefore know the speed capabilities of its children, by looking in the last self-ID packet received from each child before TX_IDENT_DONE
- A Beta capable parent node will identify from the self-ID packets from its children whether any connected child ports are Beta capable
- Beta capable children will anticipate that they might have Beta capable parents, who would initiate the switch into Beta mode transmission
- Each Beta-capable parent will arbitrate for the bus and initiate the switch to Beta mode, for each of its Beta-capable children
  - issue - this arbitration really needs to take place before the bus settles into normal operation

Beta mode start-up - 2

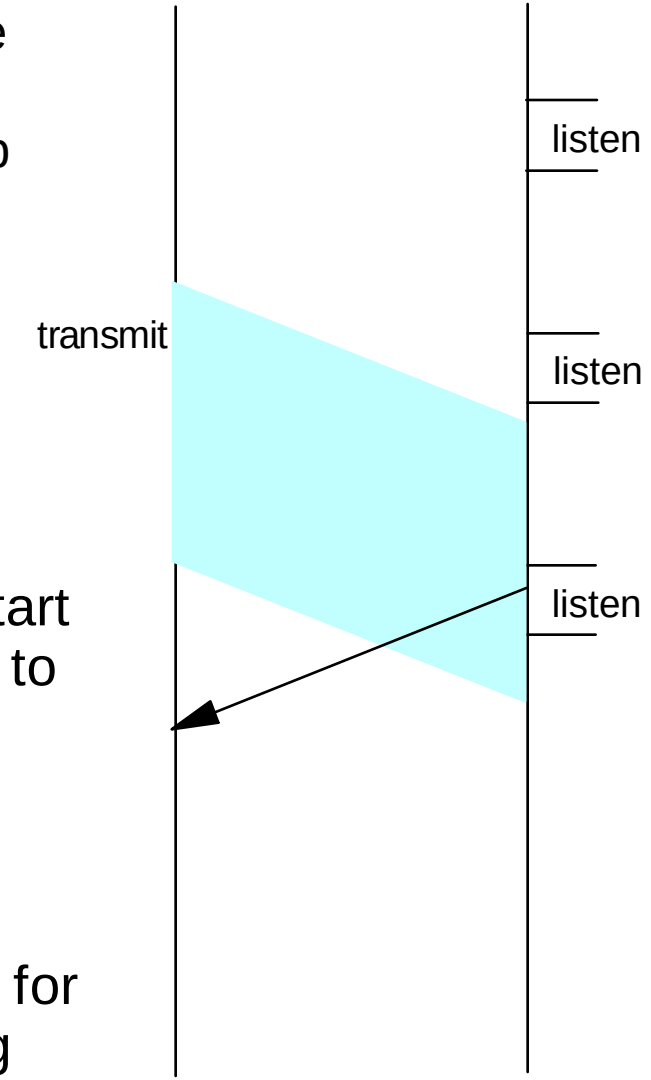
- Beta-capable parent operation:
  for each port connected to Beta-capable child node, the parent node will
  - arbitrate for the bus
  - if it wins it will
    - ✓ transmit Z1 (setting TPA to high impedance, TPA(Beta) will always appear DC high impedance as it is capacitively coupled) - this sets the transceivers up for continuous transmission on TPB and continuous reception on TPA(Beta)
    - ✓ maintain 01 (Data Prefix) on all other ports to prevent any other bus operations during this Beta mode start-up
    - ✓ initiate Beta mode (see separate presentation on synchronisation sequences)
- Beta-capable child operation:
  - be prepared for the parent to initiate Beta mode
  - the child will see an arbitration sequence, followed by Data Prefix (10)
  - the parent node may be just transmitting using DS, or may be Beta capable and trying to initiate Beta mode
    - ✓ either the port will see the incoming 10 transit to 11 or 00 (normal DS)
    - ✓ or the port will se the incoming 10 transit to Z0 (request cancel)
    - ✓ or the port will see the incoming 10 transit to 1Z; it will then prepare to receive a Beta mode initiation (this will only happen if the node which won the arbitration is this node's parent)

Beta-mode start-up - 3

- Start-up follows the following sequence
  - Both nodes repeatedly transmit a pre-defined sequence at 800 Mbps (1Gbaud) which the receiver uses for bit and byte synchronisation
    - ✓ this will be used to gain sufficient signal quality through the AC coupling components
  - After a node acquires byte synchronisation, it changes its transmit pattern (to ordinary IDLEs) to indicate this fact
  - When a node is both transmitting and receiving IDLEs, then it can start to transmit data
  - This is an over-simplified view of the Fibre Channel algorithm - which is what should actually be used
- The nodes then exchange Self-ID packets (or use some other means) of indicating their maximum speed
  - The Teng algorithm could be used instead
  - The process above is repeated at the lesser of the maximum speed for each end of the Beta link
- The nodes then release Data Prefix on all the other ports

Power saving

- No problem in stopping a link
  - stopping includes stopping the PLLs (or whatever) to save power
  - issue is how to detect that the "other" end wants to start up
  - second issue is to differentiate between power saving shutdown and disconnect
    - ✓ only need to detect the disconnect when we need to start-up again (???)
  - Could use TpBias, but it would be nice to have a solution which would also work over fully AC coupled system (e.g. optical interconnect)
- Define a period, t, which is the worst case needed to start up the PLLs, to acquire a clean signal from "cold", and to achieve bit and byte synchronisation
  - Fibre Channel says 1ms!
- Every m*t periods, start-up and listen for a period t (say, m=10)
- To start up, transmit for a period (m+2)*t (plus a factor for transmission latency), before timing out and concluding that there is no link at the other end (disconnect)



Power saving - isochronous transfers

- The algorithm on the previous page assumes that no transmissions will be requested for a period longer than m*t
- This is likely to be longer than an isochronous cycle (125us)
  - our previous presentation indicated that t needs to be 50us for AC coupled systems, optically coupled systems may require much longer
  - it is unlikely that power saving can be used when there is active isochronous traffic
- Therefore 1394a should have a facility to allow cycle starts to be turned off if there is no isochronous traffic
- This can be determined by the cycle master from the state of the plug control registers, which are now incorporated into 1394a

Beta mode power-on/reset start-up

- It is highly desirable to be "fibre ready"
  - but it will take a separate group to sort out the PMD, connector and physical media issues
  - note the current debate in Gigabit ethernet on reducing the voltage swings for copper transmission, with consequent reduction in reach - perhaps "intracabinet" only
- Fibre cannot transmit DC
- DC is currently used for
  - connection detection (voltage on TpBias)
  - Tree-ID (bi-directional digital signals)
  - Arbitration (bi-directional digital signals)
  - Speed signalling (common mode signalling)
  - Reset
- No use of DC once in Beta mode
- Therefore define a method to allow power-on start-up in Beta mode

Fibre Ready Proposal
(Beta-mode power-on/reset start-up)

- Proposal for fibre-ready spec
  - Presence of TpBias on TPB to detect either an old PHY or a bi-lingual PHY at the other end which is DC coupled to TPA(DS)
  - If no TpBias, then use the power saving technique just described for connection detection
    - ✓ establish synchronisation upon connection detection
    - ✓ after synchronisation, remember that this is a Beta-only connection, and apply reset according to usual rules
  - Use control symbols in the encoding scheme to represent the arbitration line states, including those needed for Tree ID
    - ✓ the line states themselves will have to be re-worked, as they will use full-duplex rather than 1's dominant signalling
    - ✓ issue of whether to transmit the control symbol once, followed by IDLEs, or to transmit the control symbol continuously until the line state changes
  - after establishing synchronisation (at 800 Mbps), proceed with Tree-ID using control symbols
  - use control symbols to implement arbitration for Self-ID packets
  - after Self-ID, select the final speed for Beta-capable ports as previously described
  - do not drop back to ordinary DS mode on reset
- Fully compatible with bi-lingual operation