1000BASE-T Duffer's Guide to Basics and Startup

Steve Pryor

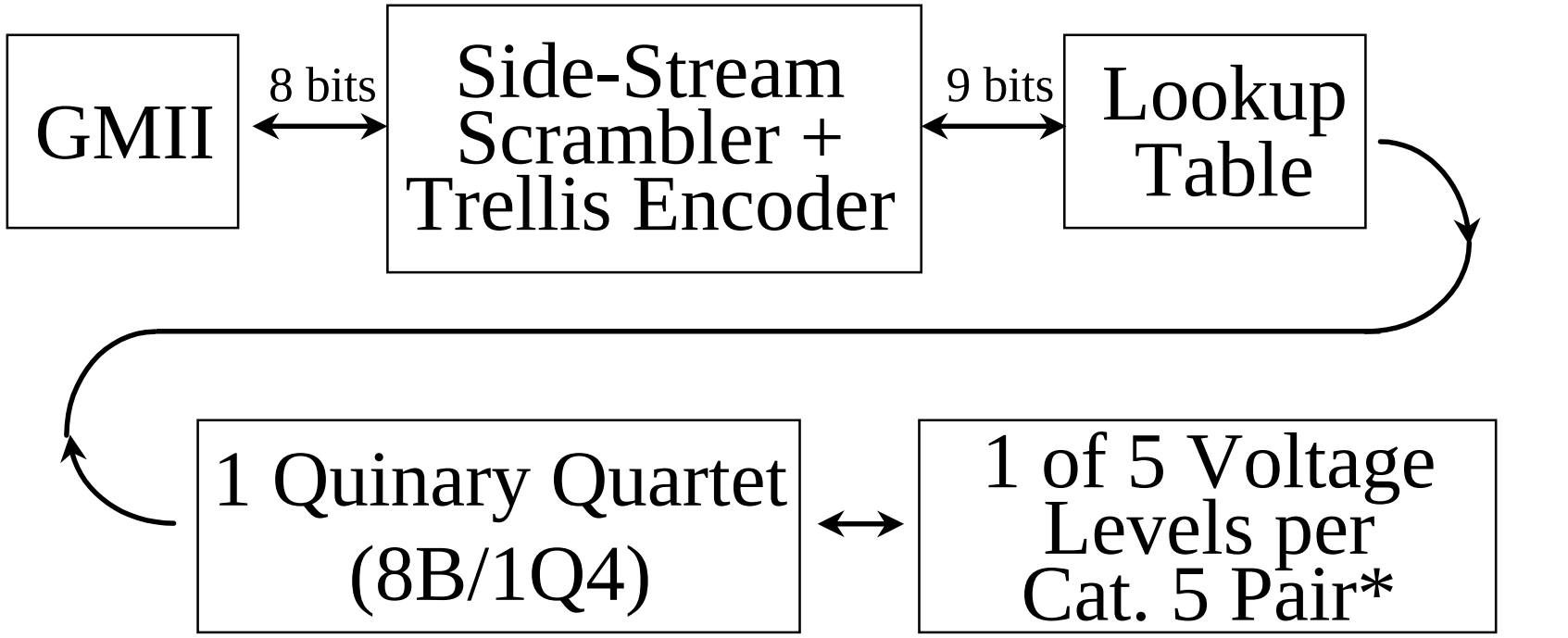
Manager, Training Development Services

Compaq Computer Corporation

1000BASE-T Basics

- 1000 Mb/s using 4 pairs of Cat 5 UTP Cable
- Distance: 100 Meters
- Half or Full Duplex
- TX and RCV simultaneously on all 4 pairs

Data Flow



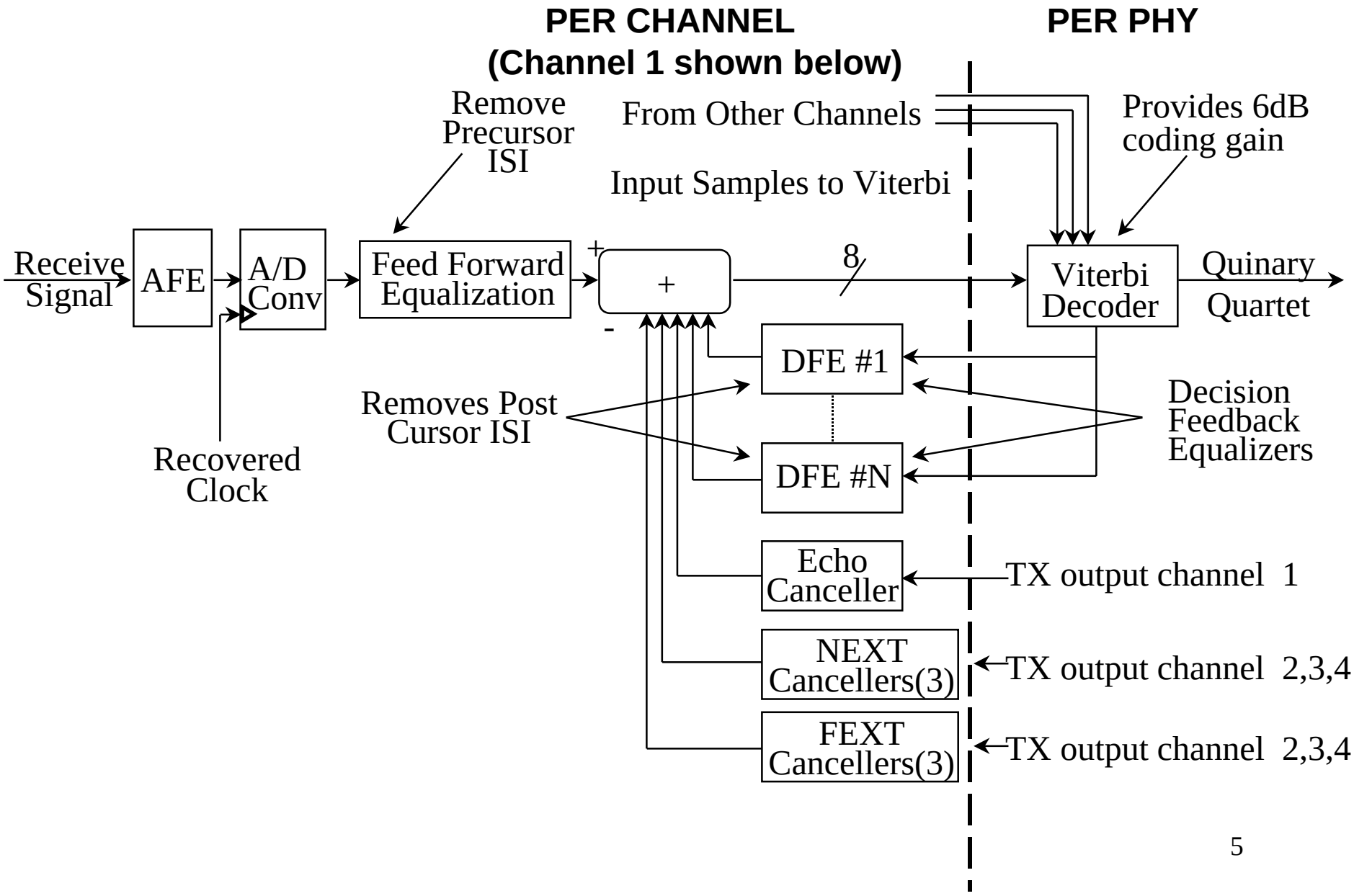
01001010 ↔	101011010 ↔	+1, 0, -2, -1 ↔	+0.5, 0.0, -1.0, -1.0

* Actually 17 voltage levels to reduce emissions by shaping the output

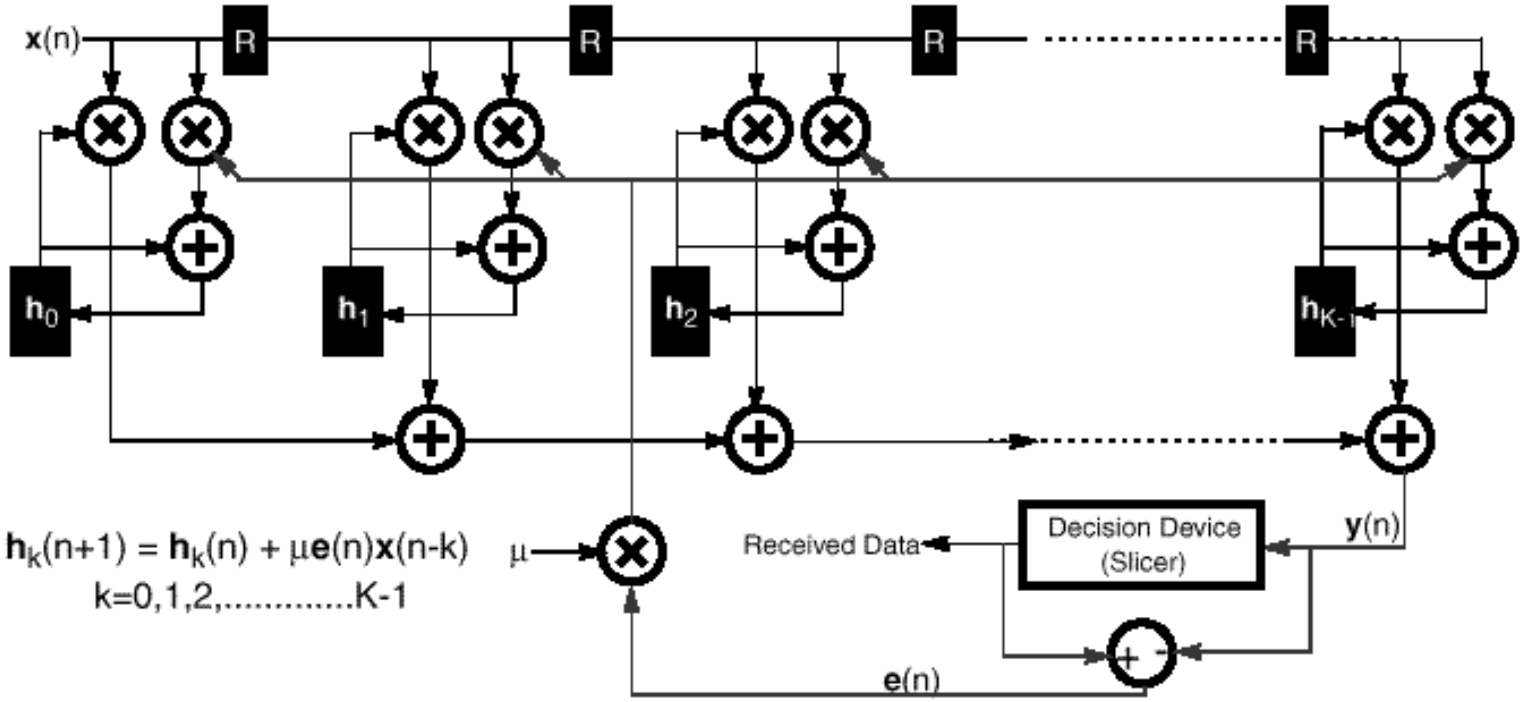
The requirements (What 1000BASE-T has to do)

- Maintain timing synchronization between slave and master
- Successfully receive signals on four pair at 125MBAUD
- Successfully perform the following within timing constraints (8ns):
  - Remove ISI through equalization
  - Remove ECHO (from near-end XMT and its channel reflection)
  - Remove NEXT (from each of other three pairs)
  - Remove FEXT (from each of other three pairs)
- Recover the correct code group from the 4D-PAM5 signals recovered
  - uses a Viterbi decoder
- Descramble the recovered code group

Gigabit Receiver With FEC



Linear Equalizer with LMS Update



The equalizers, NEXT cancellers and echo cancellers in a 1000Base- T transceiver are all variations of this filter structure.

Why Start-up

- Slave must acquire clock so it can synchronize its operations to the Master's clock. This relationship must be maintained on an on-going basis.
- Both Master and Slave must "train" all 36 adaptive equalizers so they "understand" the noise on the link (and elsewhere) and are prepared to filter it.
- Train equalizers (DFE, FFE)
- Train noise cancellers (Echo, NEXT, FEXT)

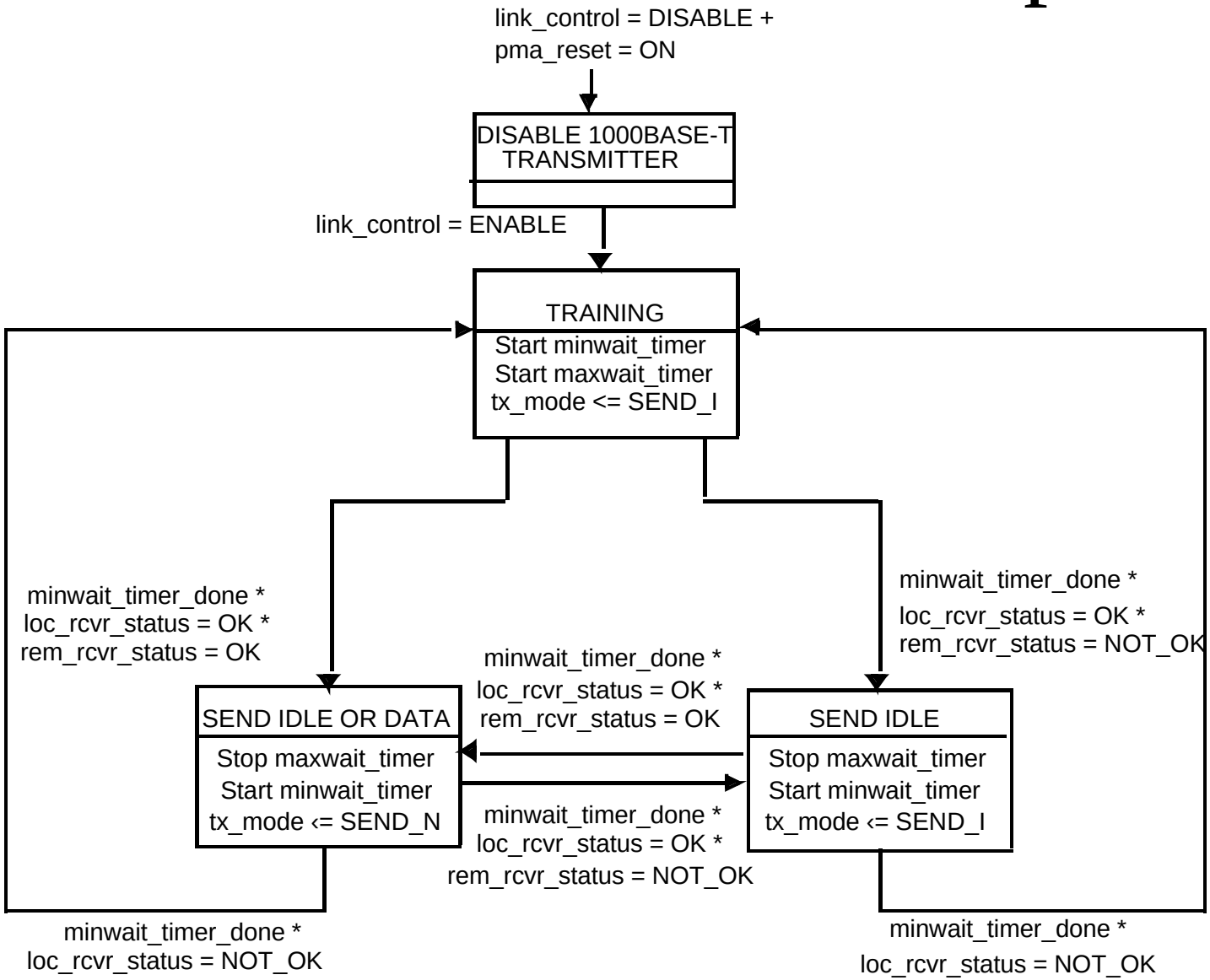
Problems at start-up

- Signal analysis complexity in the receiver at start-up
  - ISI
  - Return loss (from impedance mis-matches in the channel)
  - Echo (from this channel's TX)
  - NEXT (from 3 pair's TX)
  - FEXT (from 3 pair's far-end TX)
  - External noise
- Easier to train equalizers in the absence of echo

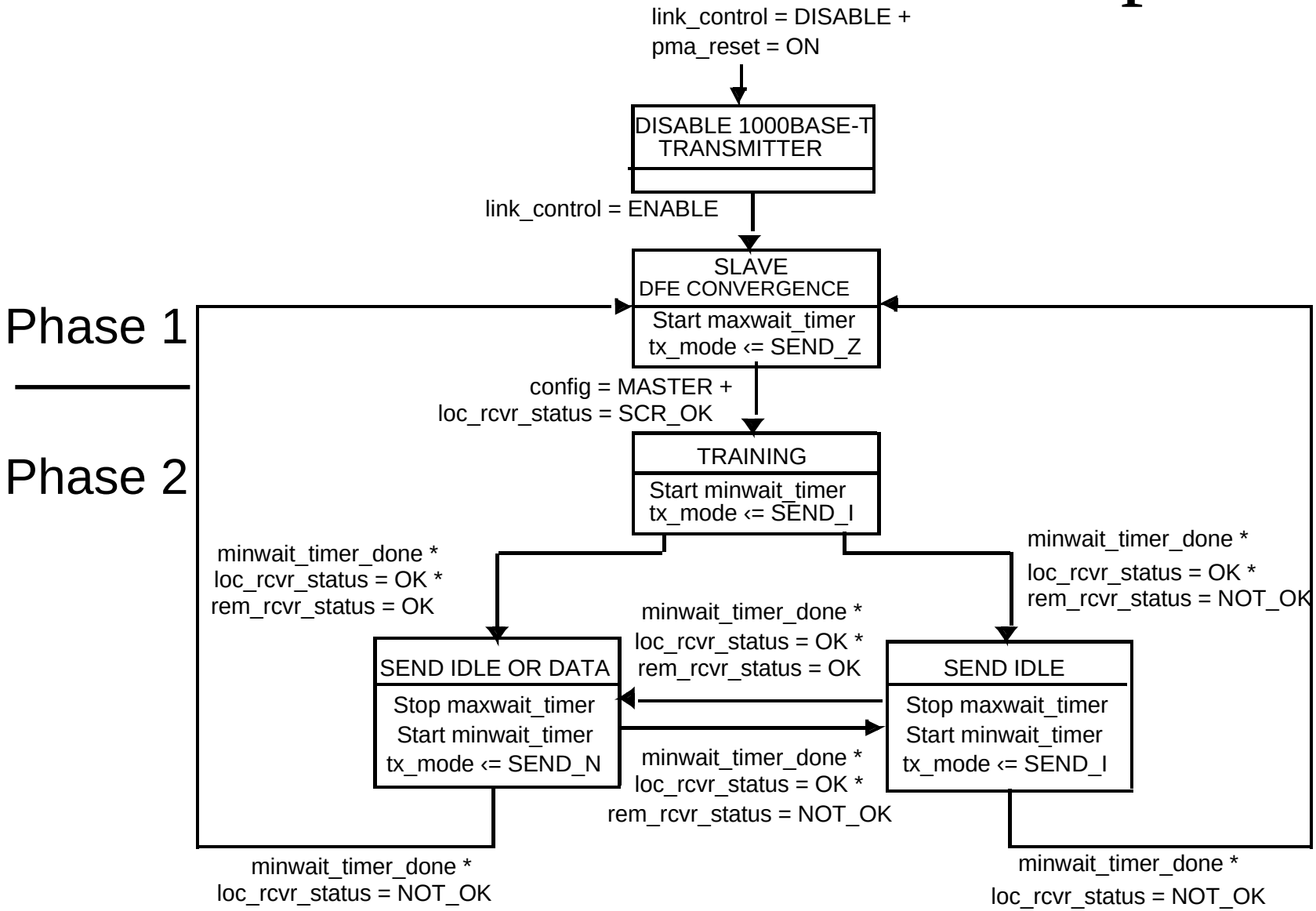
The “Smart Blind” Solution

- Maintains the implementation simplicity of blind start-up.
- Slave delays transmitting up to 350 ms (should be less than 10 ms) to provide the opportunity for equalizer training without echo before blind start-up activities begin.

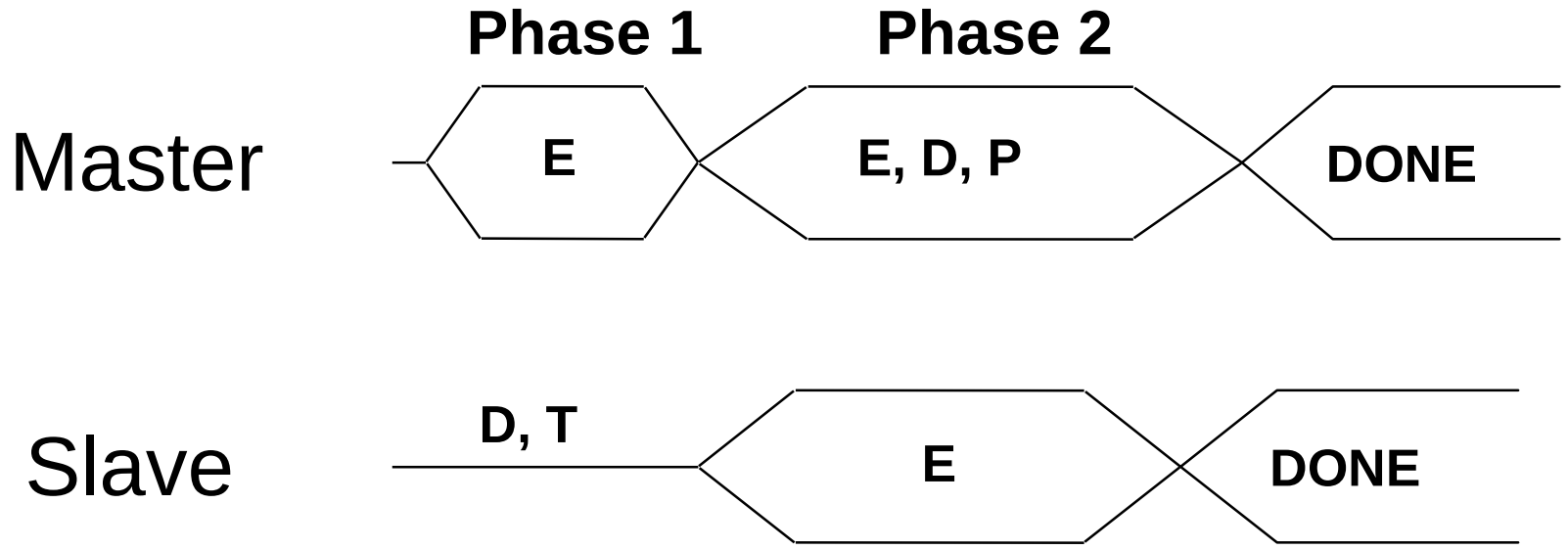
“Classic Blind” Start-up



“Smart Blind” Start-up



“Smart” Blind Start-up



E = Echo/NEXT Canceller Convergence
T = Timing Convergence
P = Adjust Phase
D = Equalizer Convergence