Evaluation of the Synchronized Three-Phase Startup

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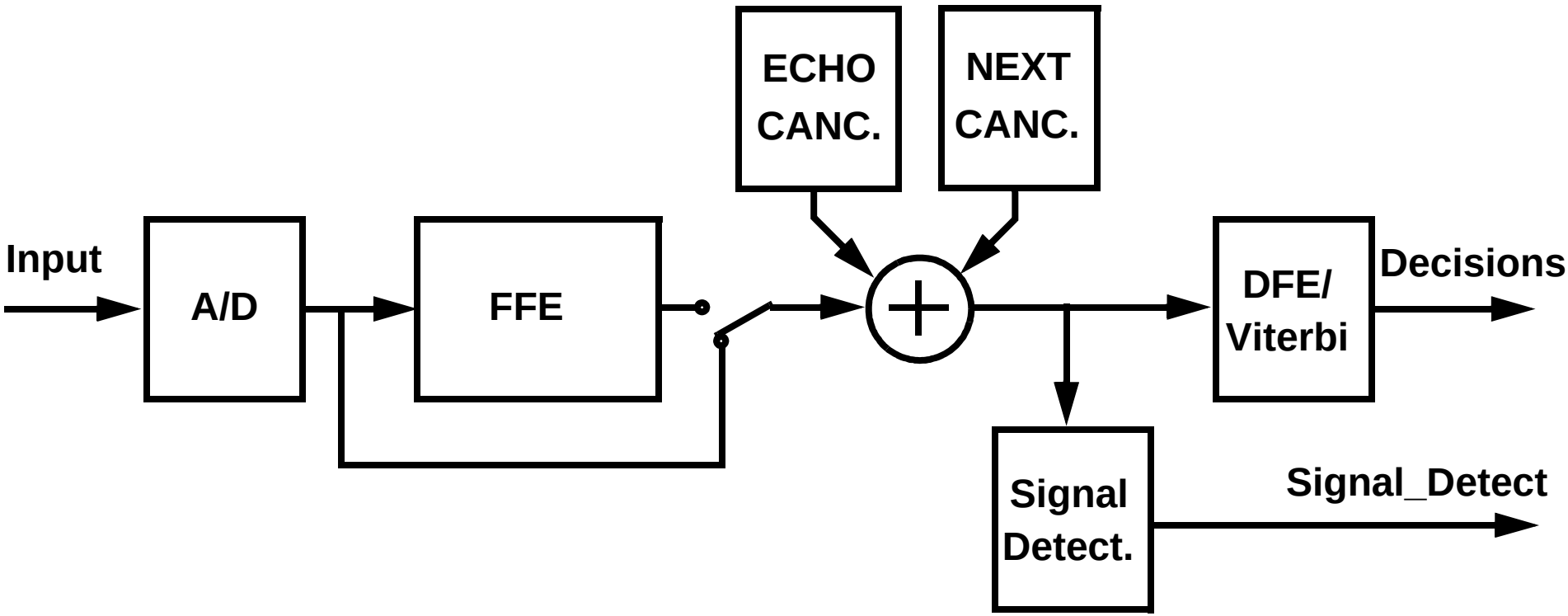
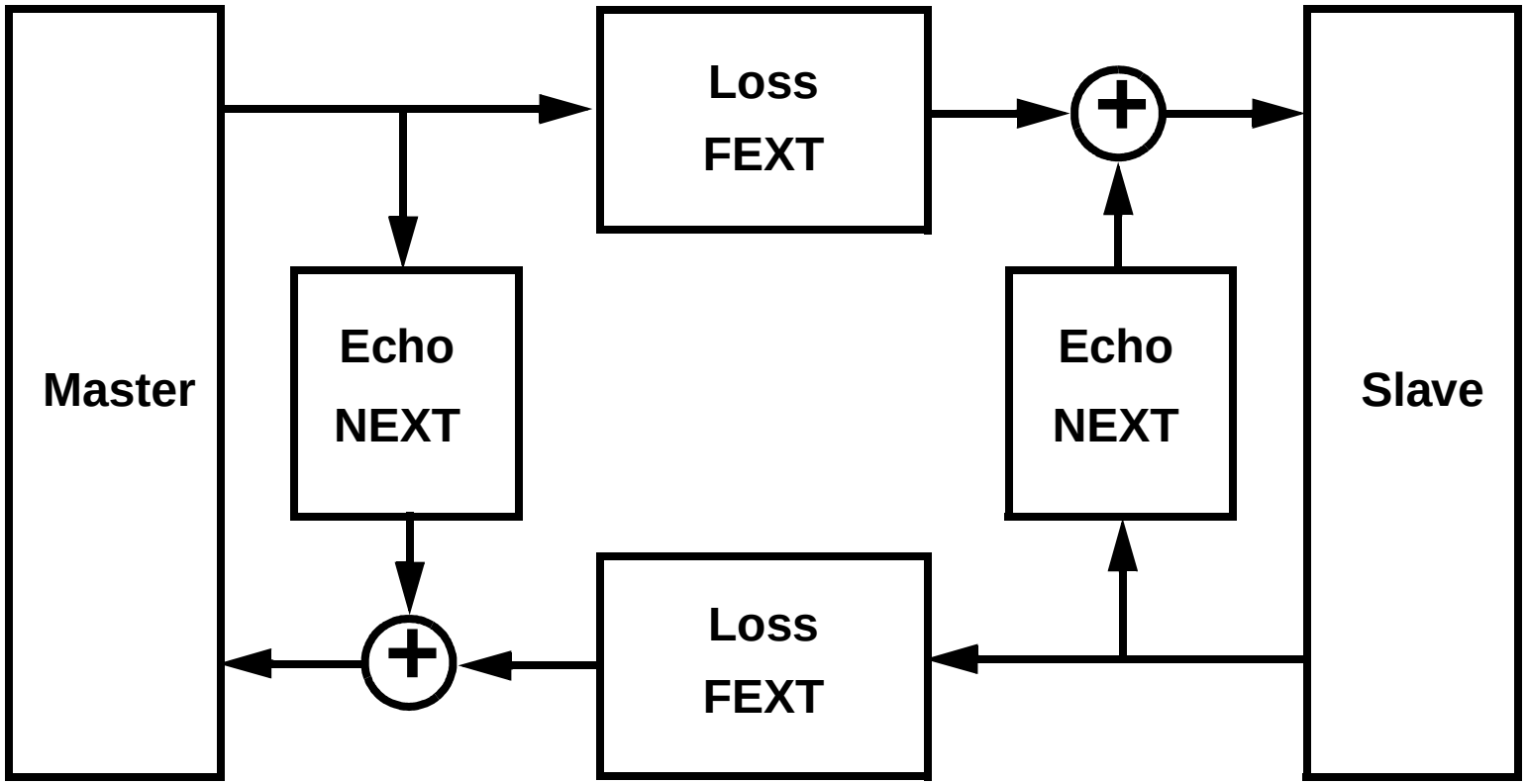
Overview

- **Simulation of Signal Detector**
- **Simulations of Startup State Machine**
- **Probability of restart**
- **Fast Link Pulses (FLP) and signal detect**
- **Conclusions**

Signal Detection in an Echo Cancellation Environment



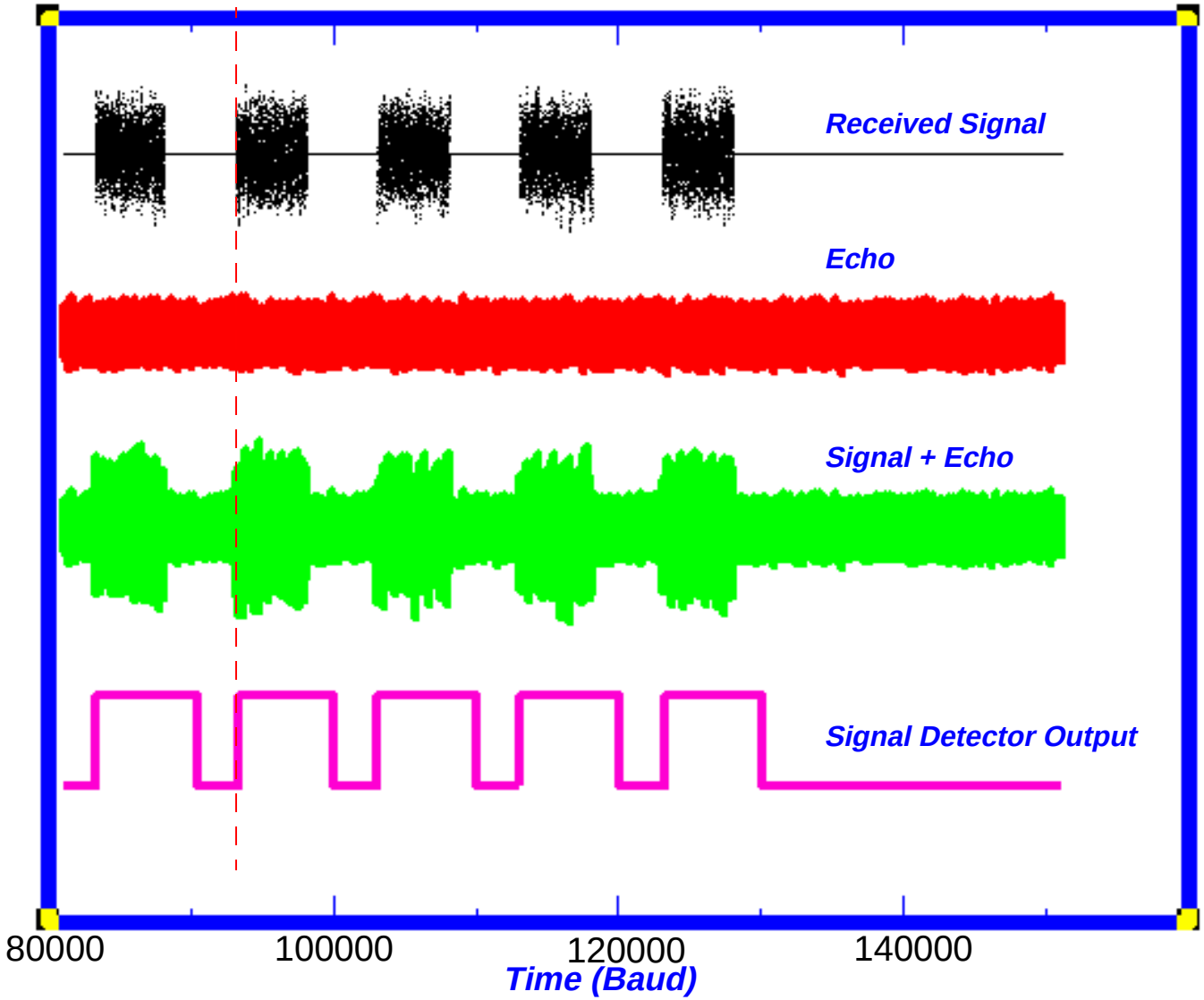
Simulation Model

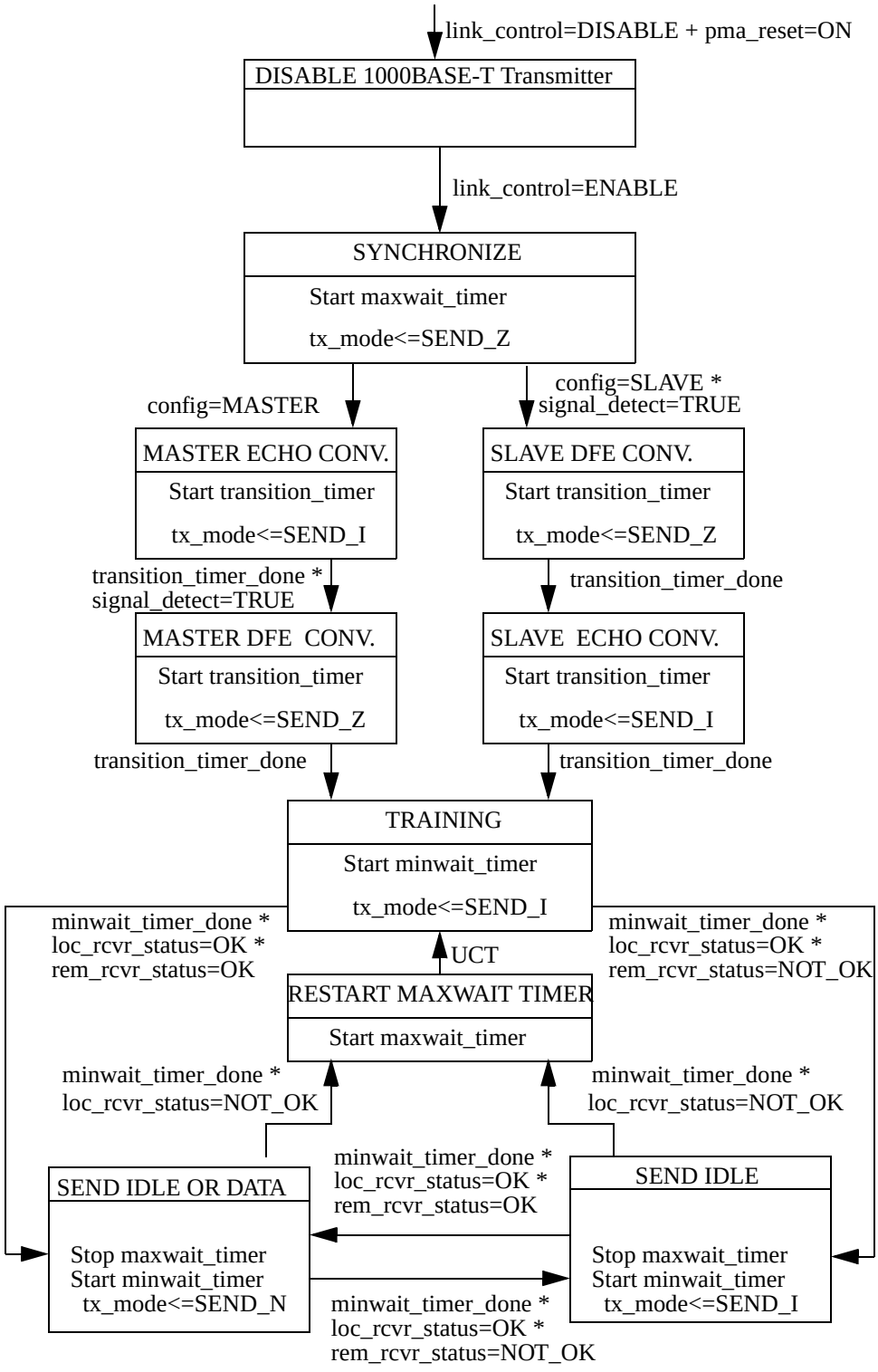


Features of Simulation Environment

- **Complete handshake between Master and Slave is captured**
- **Fully asynchronous simulation, with 200ppm initial frequency offset between Master and Slave clocks**
- **All details of adaptive filter convergence and timing recovery (frequency and phase) captured**
- **Transmitter fully compliant with current draft (D1.2) of the PCS**
- **All startup sequencing is done automatically under PHY_CONTROL**
- **Signal detector triggers transitions from Phase I to Phase II at the Master and from SYNCHRONIZE to Phase I at the Slave**

Signal Detector Simulation Results

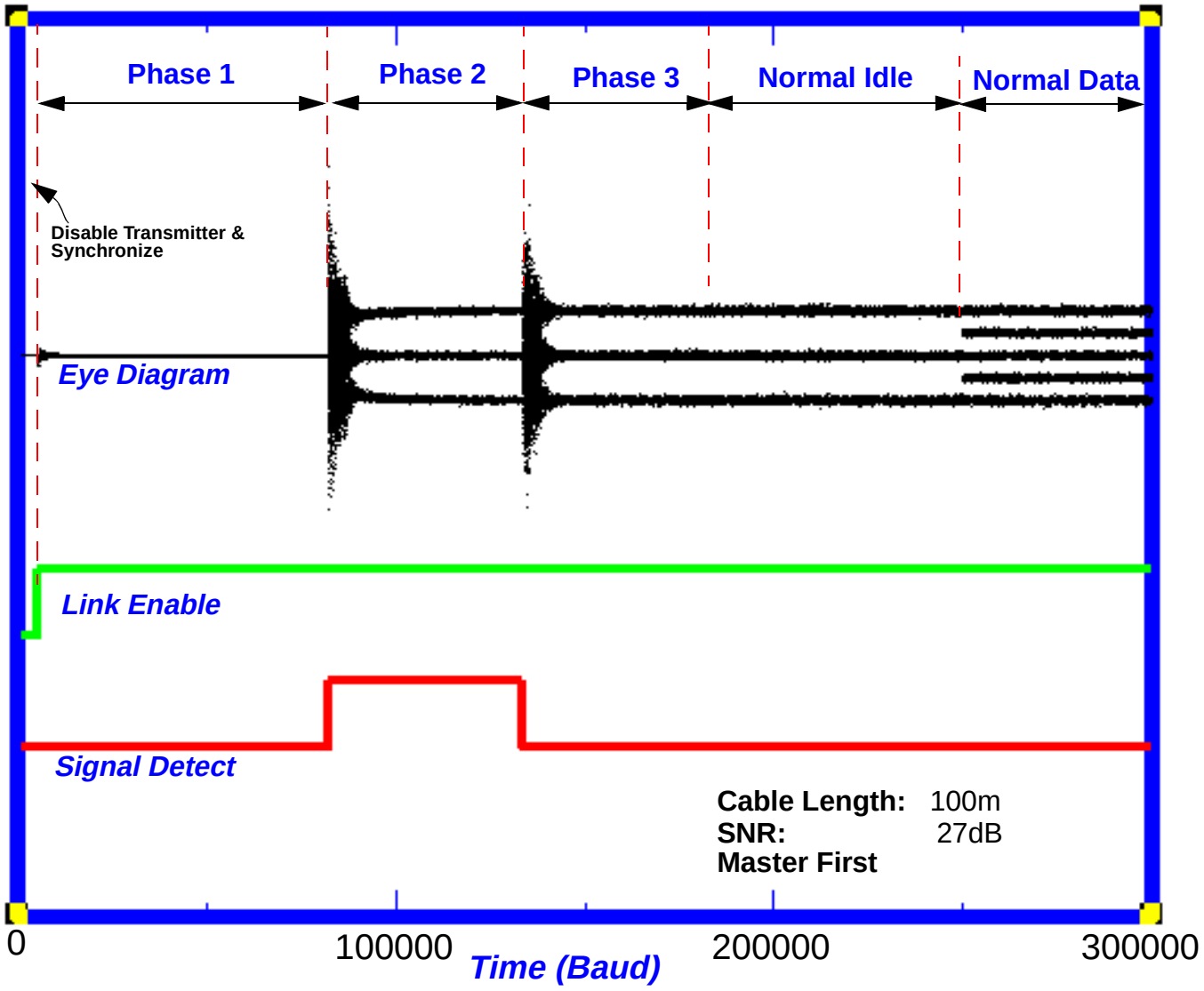



link_control=DISABLE + pma_reset=ON
DISABLE 1000BASE-T Transmitter
link_control=ENABLE
SYNCHRONIZE
Start maxwait_timer
tx_mode<=SEND_Z
config=MASTER
config=SLAVE *
signal_detect=TRUE
MASTER ECHO CONV.
Start transition_timer
tx_mode<=SEND_I
SLAVE DFE CONV.
Start transition_timer
tx_mode<=SEND_Z
transition_timer_done *
signal_detect=TRUE
transition_timer_done
MASTER DFE CONV.
Start transition_timer
tx_mode<=SEND_Z
SLAVE ECHO CONV.
Start transition_timer
tx_mode<=SEND_I
transition_timer_done
transition_timer_done
TRAINING
Start minwait_timer
tx_mode<=SEND_I
minwait_timer_done *
loc_rcvr_status=OK *
rem_rcvr_status=OK
UCT
minwait_timer_done *
loc_rcvr_status=OK *
rem_rcvr_status=NOT_OK
RESTART MAXWAIT TIMER
Start maxwait_timer
minwait_timer_done *
loc_rcvr_status=NOT_OK
minwait_timer_done *
loc_rcvr_status=NOT_OK
minwait_timer_done *
loc_rcvr_status=OK *
rem_rcvr_status=OK
SEND IDLE OR DATA
Stop maxwait_timer
Start minwait_timer
tx_mode<=SEND_N
SEND IDLE
Stop maxwait_timer
Start minwait_timer
tx_mode<=SEND_I
minwait_timer_done *
loc_rcvr_status=OK *
rem_rcvr_status=NOT_OK

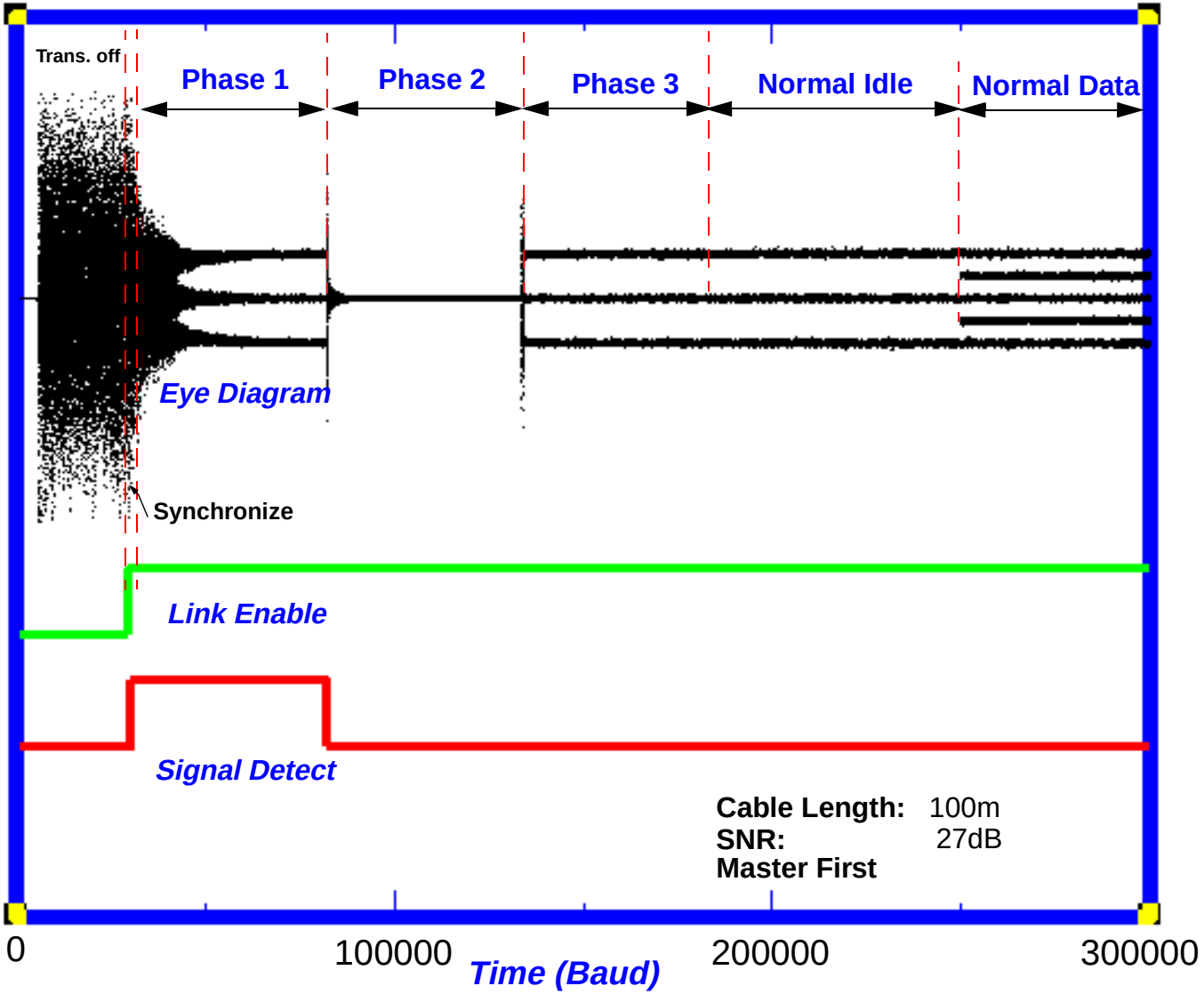
Startup State Machine Cases Simulated

- **CASE 1: Master ends autonegotiation first. Cable length 100m. Normal SNR (27dB)**
- **CASE 2: Slave ends autonegotiation first. Cable length 100m. Normal SNR (27dB)**
- **CASE 3: Slave ends autonegotiation first. Cable length 100m. Low SNR (21dB)**
- **CASE 4: Slave ends autonegotiation first. Cable length 0m. High SNR (33dB)**
- **CASE 5: Slave ends autonegotiation first. Cable length 140m. Normal SNR (26dB)**

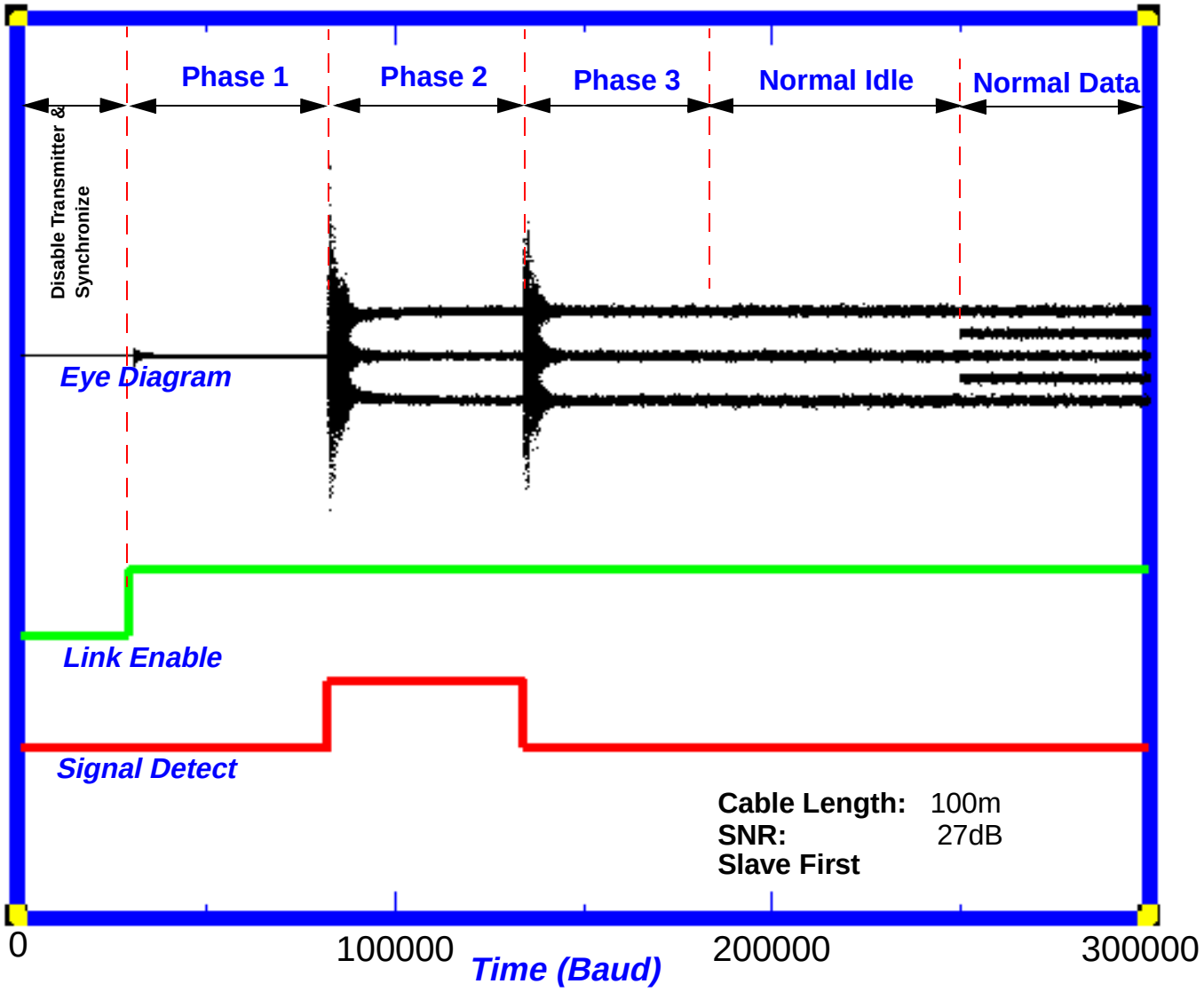
Sequenced Startup (master)



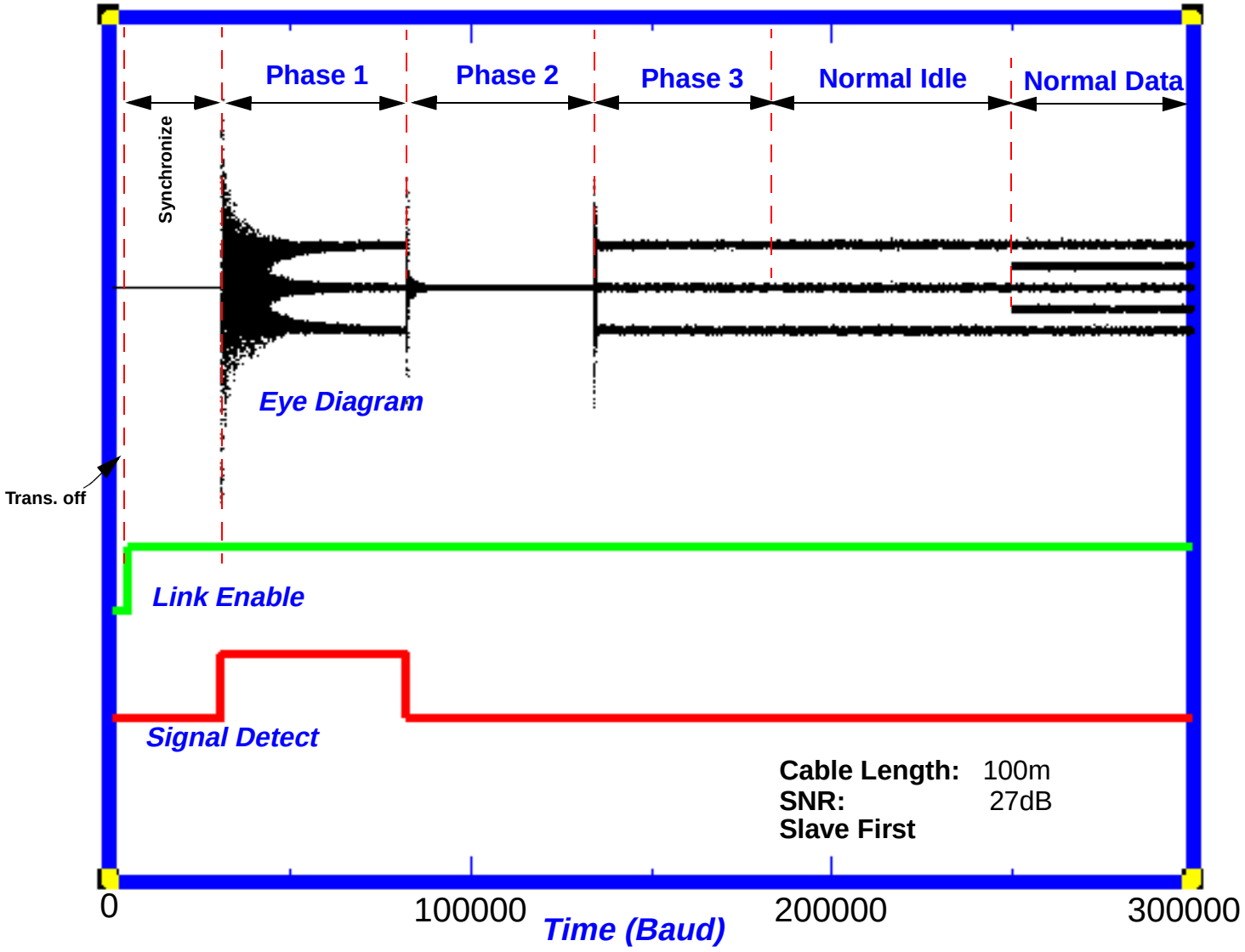
Sequenced Startup (slave)



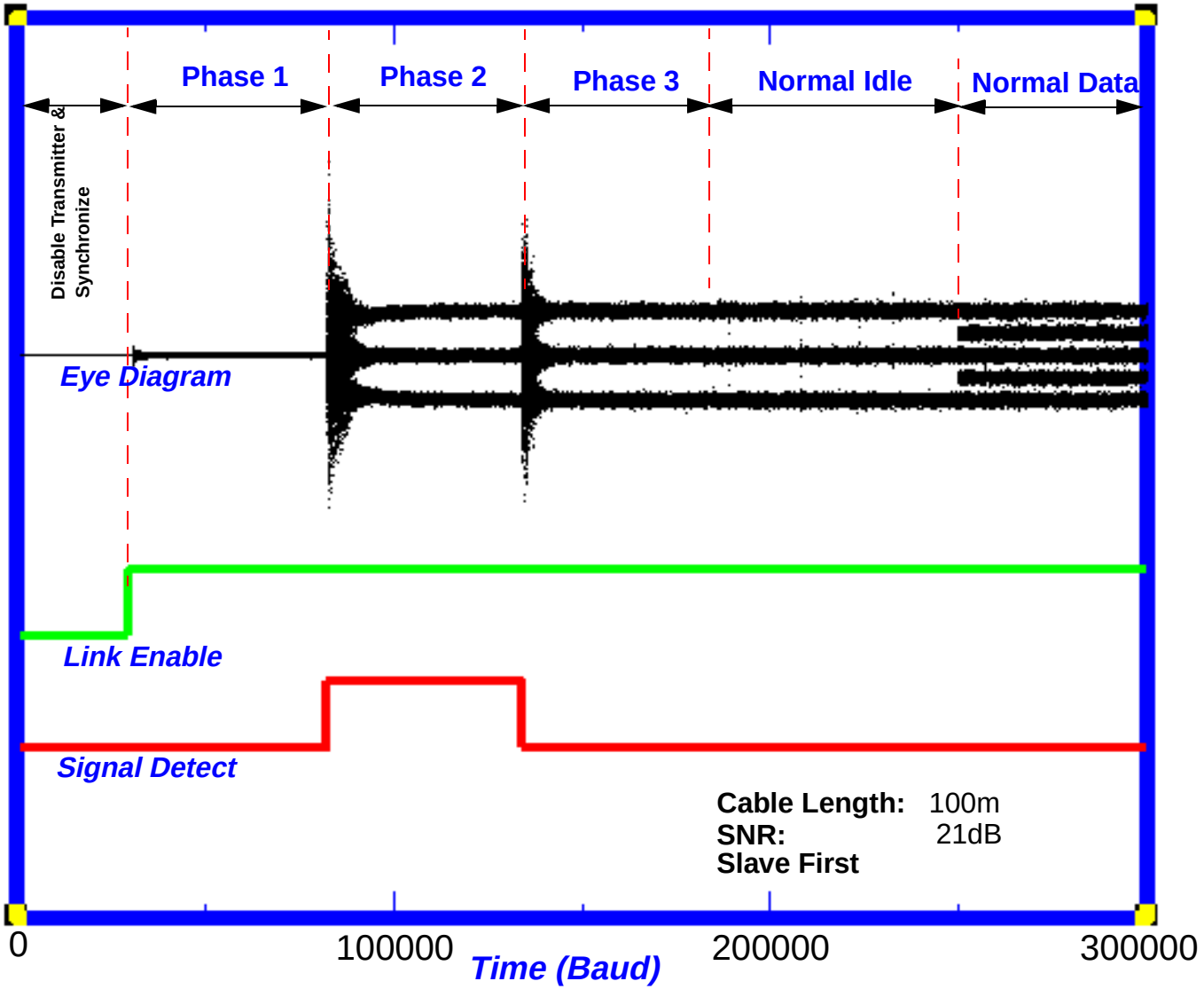
Sequenced Startup (master)



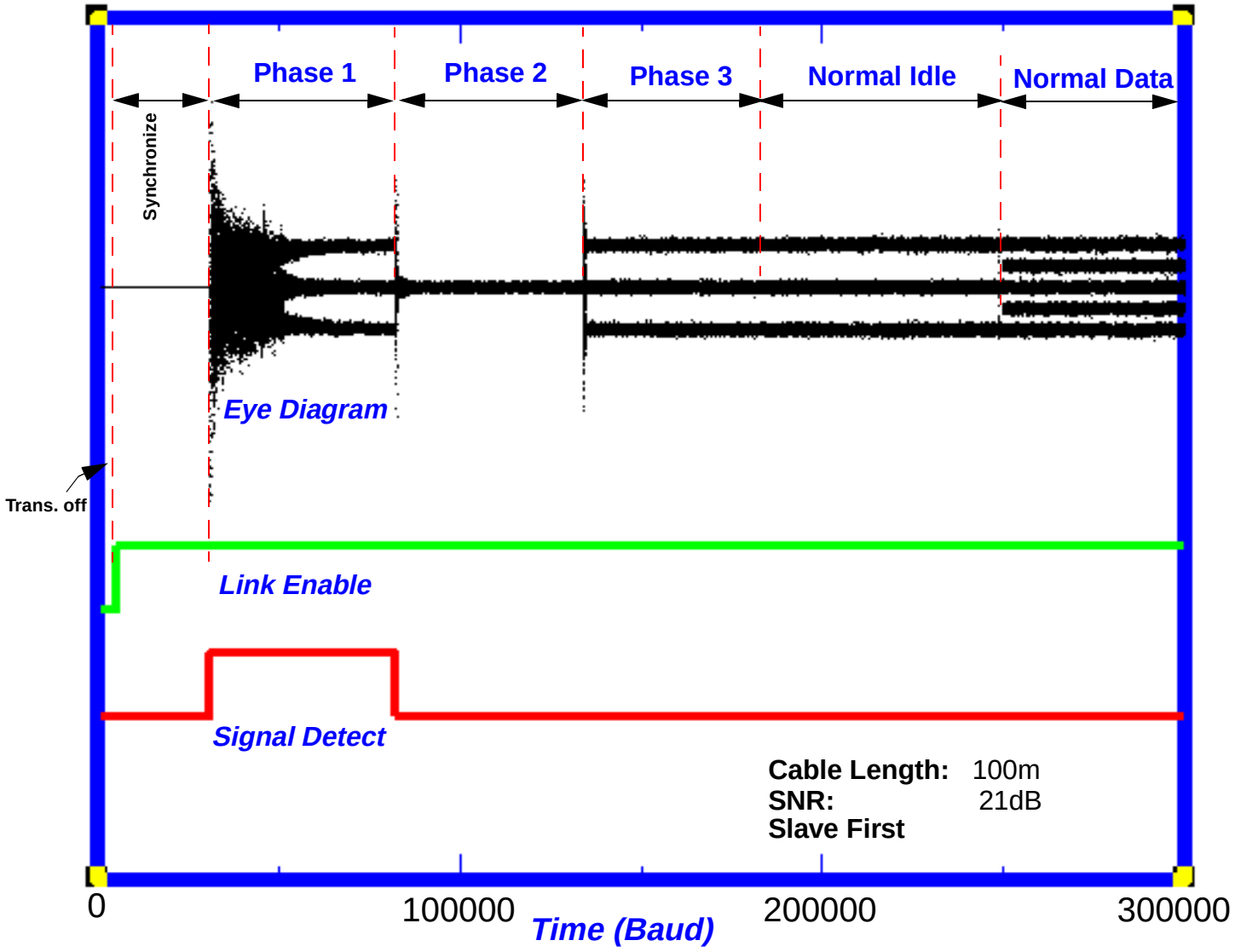
Sequenced Startup (slave)



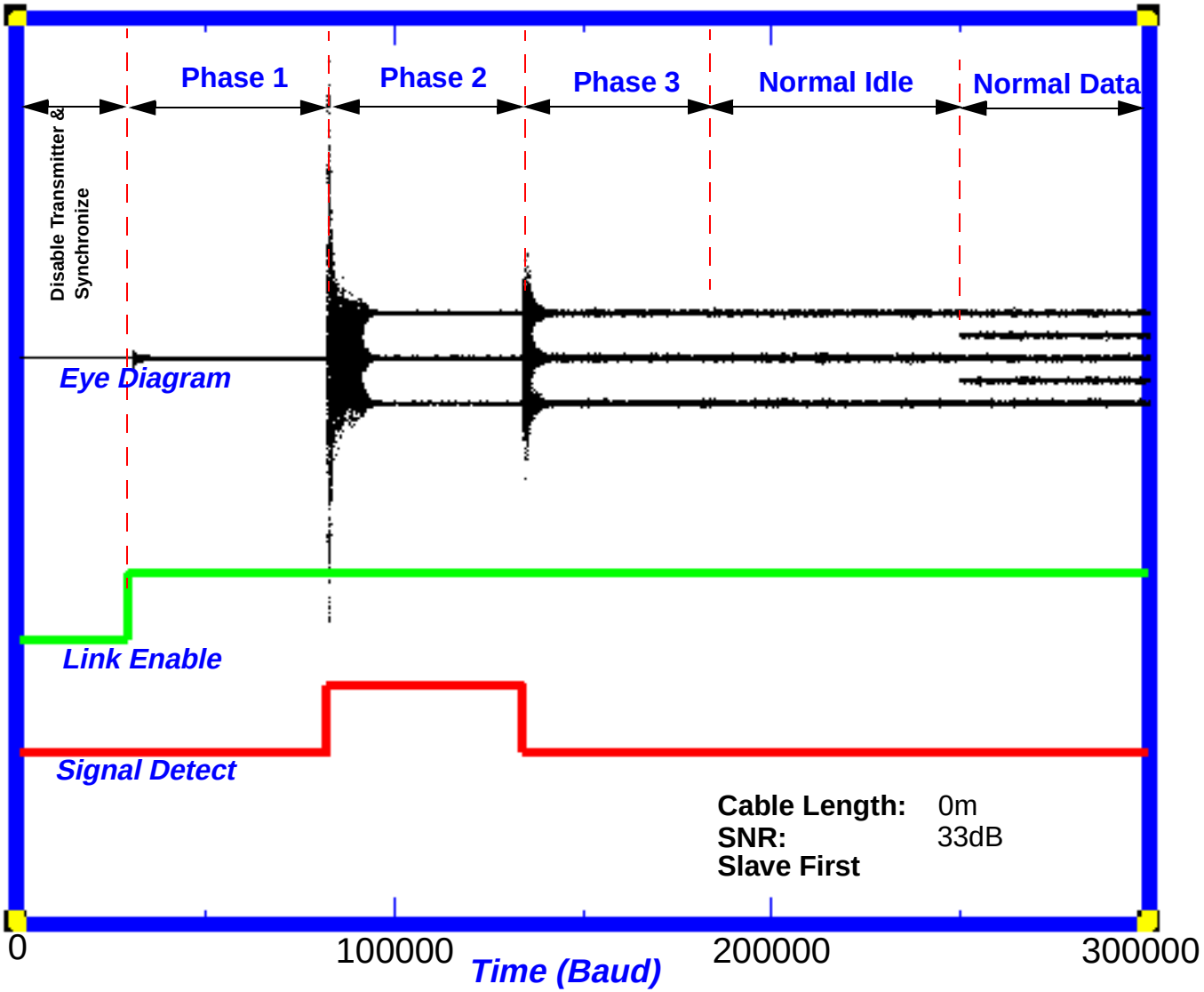
Sequenced Startup (master)



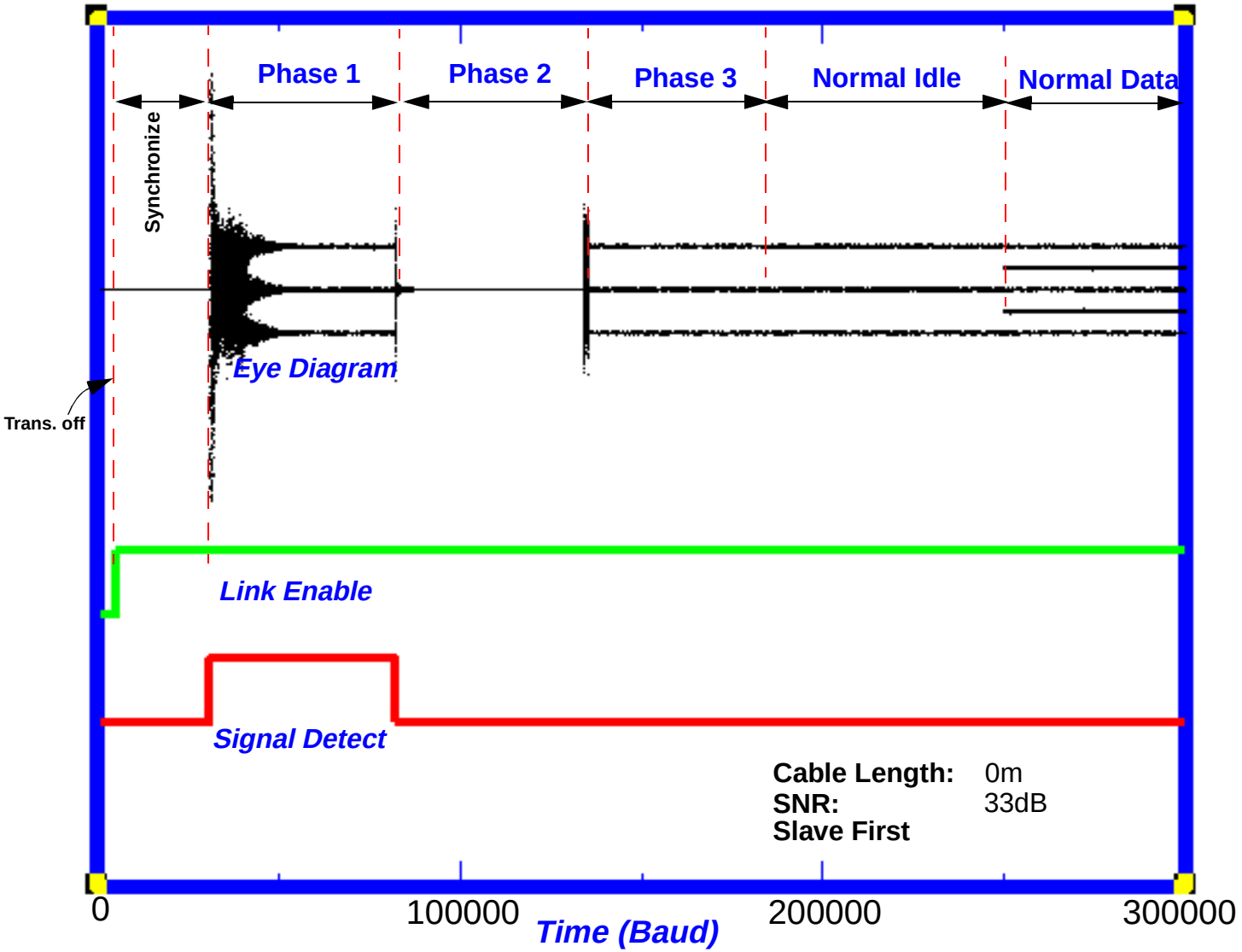
Sequenced Startup (slave)



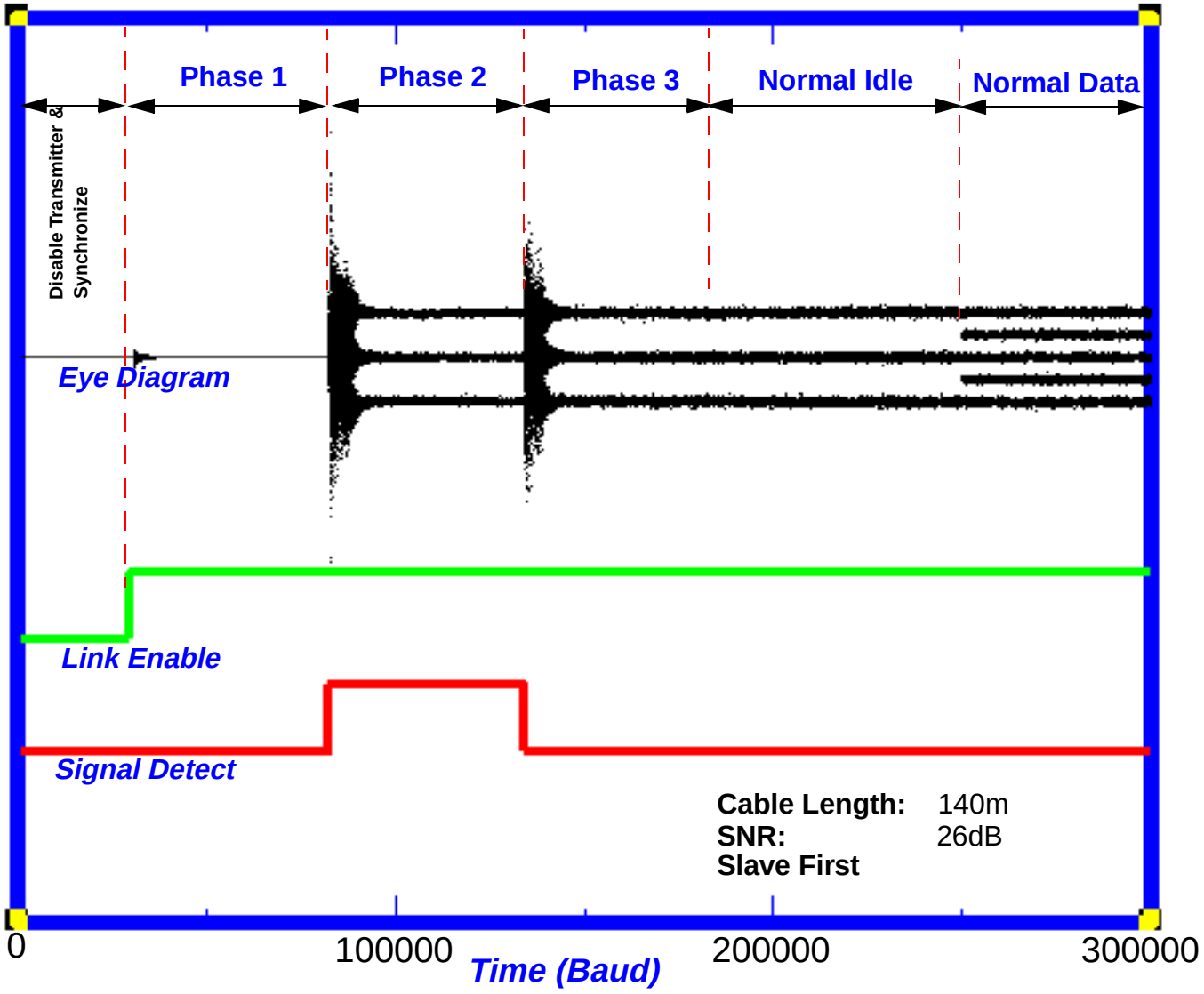
Sequenced Startup (master)



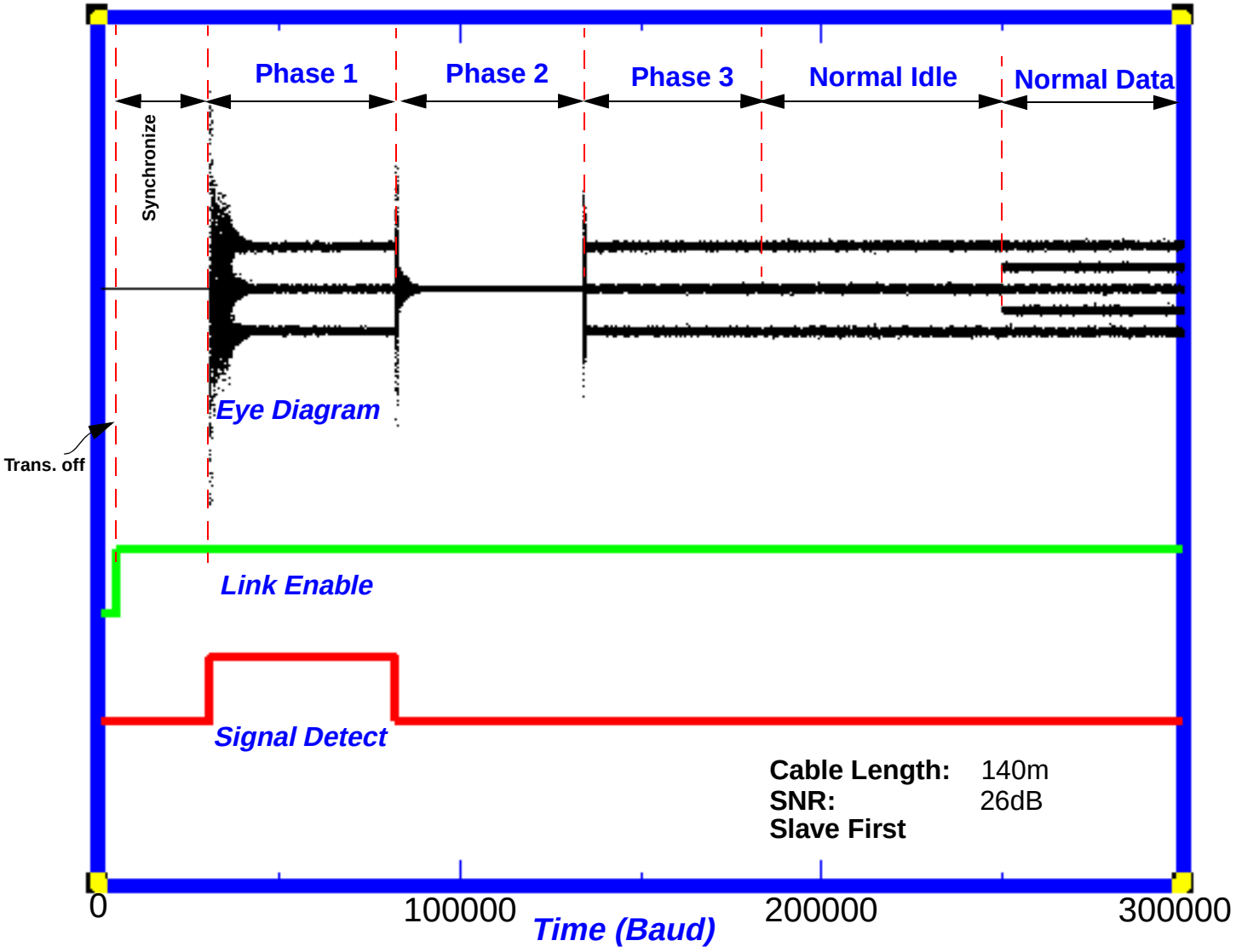
Sequenced Startup (slave)



Sequenced Startup (master)



Sequenced Startup (slave)



Probability of Retries

- **Extreme noise conditions are required to cause false signal detect and a potential restart of autonegotiation during startup. (Noise must be greater than 350 mv peak and present simulatenously on all 4 pairs).**

- **Extreme noise can only restart autonegotiation by causing false signal detections if it falls in a window of less than 210 ms during startup.**

- **Noise within channel spec limits will not cause a retry of startup via autonegotiation**

Extreme Scenario

- **Assume extreme noise spikes, exceeding spec limits, 32ns wide, at a rate allowing normal operation (<10^{-10} BER) are present.**
- **Assume noise spikes are present simultaneously on all four pairs so that a false signal detect can be generated.**
- **Assume that noise spikes of smaller magnitude that would cause interference with normal operation but not signal detect are not present.**

Extreme Scenario (cont.)

- Then each spike would cause on average (1/2)*4*8=16 bit errors. For a BER=10^{-10} the spikes would occur at a rate of one every 160 seconds.
- The probability that a spike would hit the 210 ms window during startup is 0.0013.
- Thus under unreasonably bad conditions and extreme assumptions, one out of about 1000 times autonegotiation would have to be restarted.

Probability of Retry Conclusion

- **False signal detection causing retries of startup via autonegotiation are not an issue.**

FLP Issues

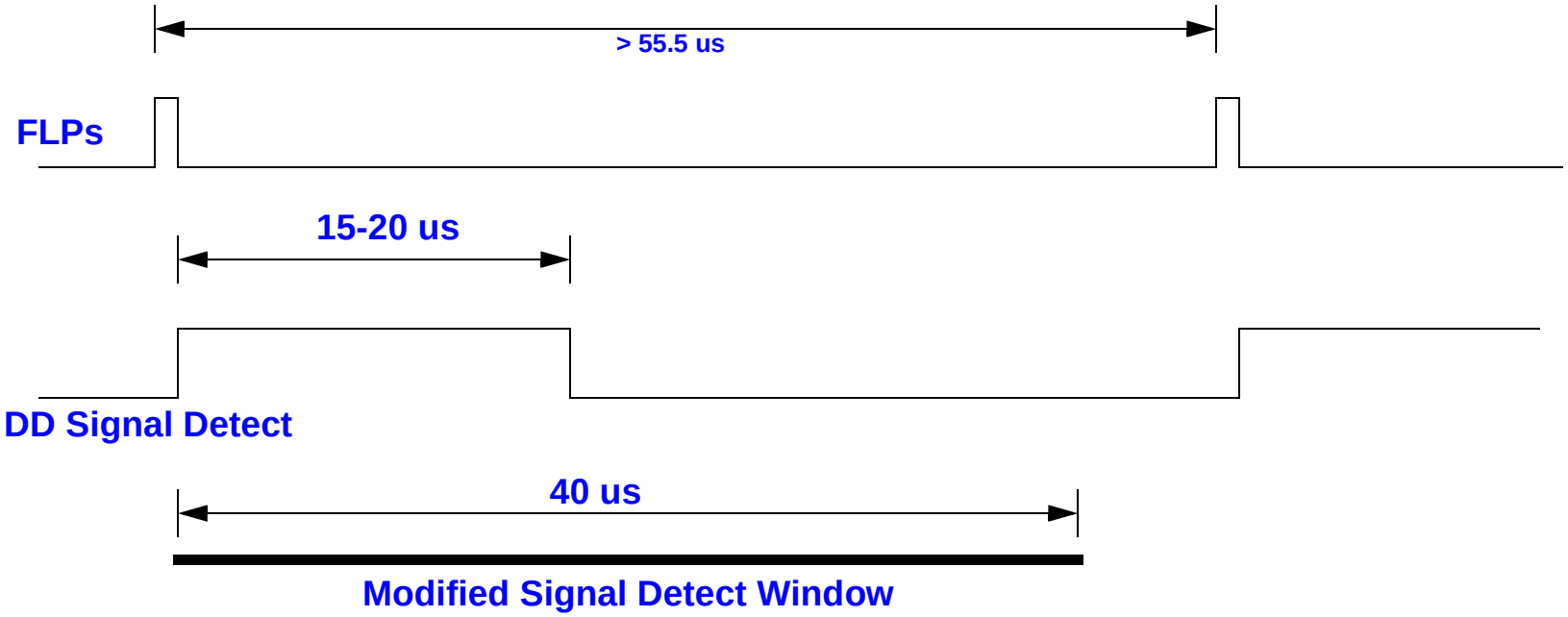
- **Proposed signal detector rejects FLPs by requiring signal to be present on all 4 pairs before declaring signal_detect=TRUE. Since FLPs are generated on one pair, they will not result in signal_detect=TRUE.**

- **If a scheme for pair-insensitive autonegotiation is proposed which sends FLPs on all 4 pairs, signal detect should be modified to reject FLP pulses as follows.**

Signal Detect for 4 pair FLPs

- **Use Dan Dove signal detect as basis**
- **Additionally require that Dan Dove signal detect continuously indicate signal_detect=TRUE for 40 us before indicating signal_detect=TRUE to PHY Control**
- **FLPs have a nominal width of 100 ns and are separated by a minimum of 55.5 us so therefore will not trigger the signal detect.**

Modified Signal Detect Example



Modified Signal Detect

Conclusions

- **Signal detector proposed by Dan Dove meets requirements of 1000Base-T and is very robust**
  - Insensitive to FLP pulses
  - With simple modification can accommodate autoselect
- **Startup state machine is fully consistent with startup protocol approved in Montreal**
- **Extensive simulations of startup state machine done**
- **Probability of restart is extremely small even under outrageous noise conditions**