A Risk-Free Startup Protocol for 1000BASE-T

Sailesh K. Rao
Level One Communications, Inc.

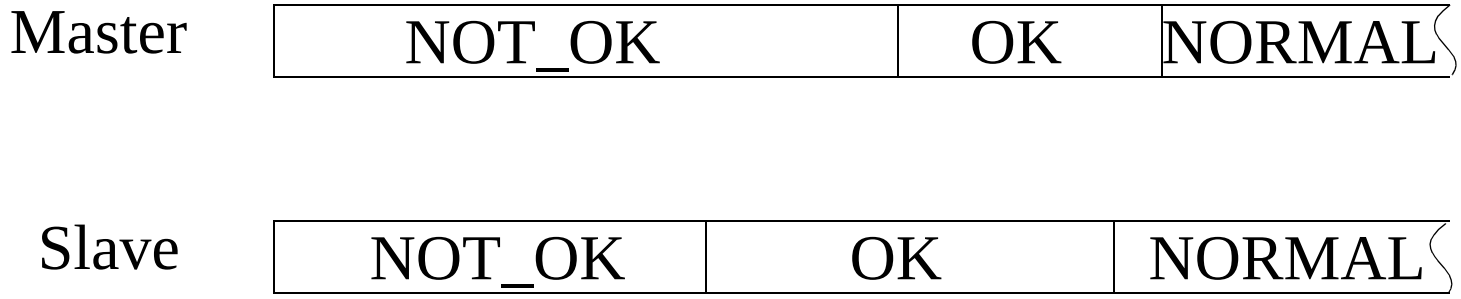
LEVEL ONE

Outline

- Blind Startup with 3-level Signalling
- Simulation Results for Blind Startup
- Risk-Free Sequenced Startup Protocol
- Simulation Results
- Conclusions

Blind Startup with 3-level Signalling

- 3-level NOT_OK/OK Idle Signalling during tx_mode=SEND_I



- Slave converges first, then Master.

LEVEL ONE

Simulation Setup

- Worst-Case Environment

  BRC measured echo/channel/NEXT models
  Transmit/Receive Filtering as in Matlab code
  3dB design point used

- Worse-than-Worst-Case Environment

  BRC measure channel/NEXT models
  BRC echo model scaled up by 6dB
  100mV ptp sinusoidal interferer added
  Transmit/Receive filtering as in Matlab code
  3dB design point used

LEVEL ONE

Blind Startup Algorithm

- Adjust FFE/DFE/timing for X cycles

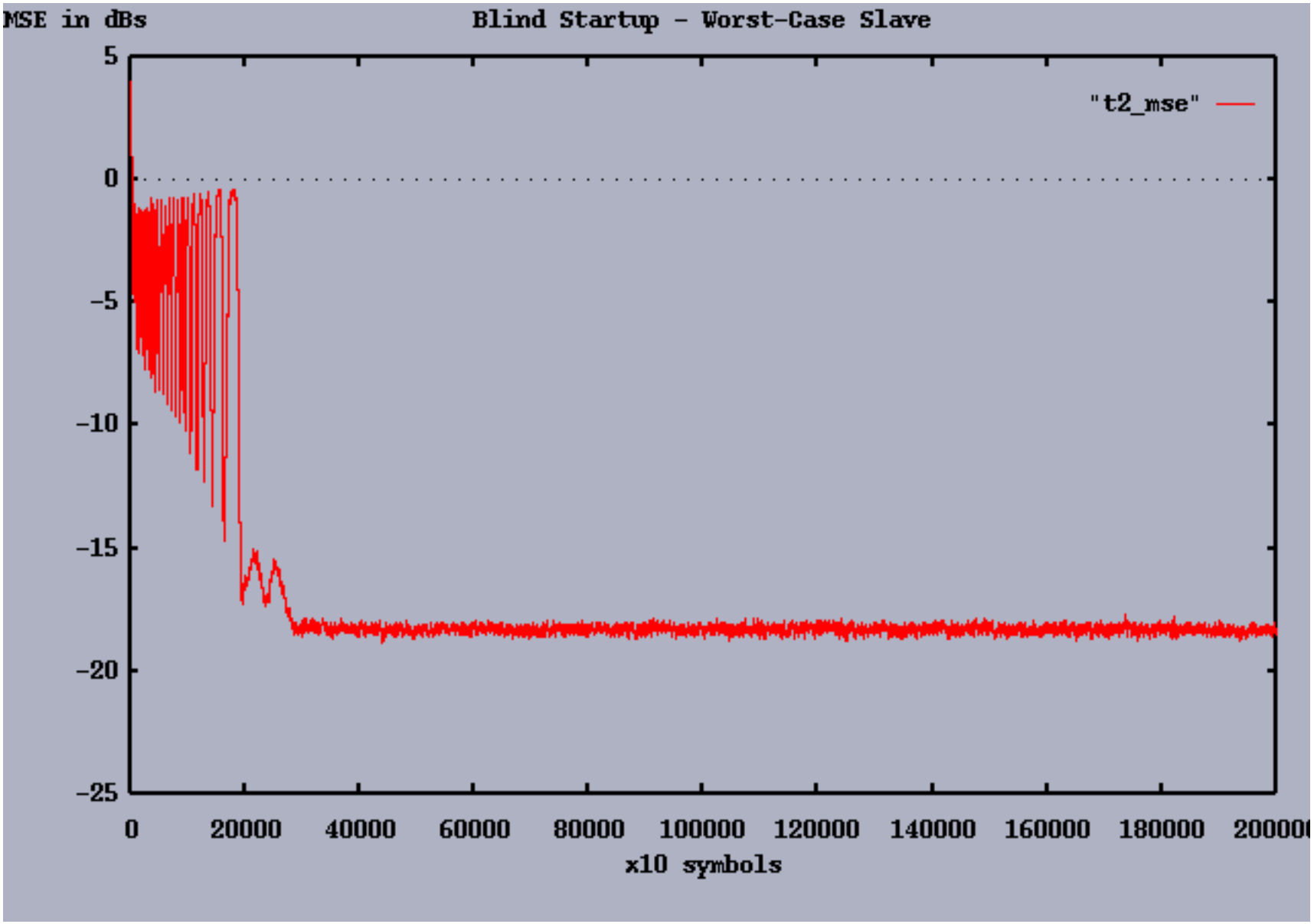
  X is the lesser of
  2 increment/decrement timing updates
  32 symbol periods

- Adjust Echo/NEXT cancellers for Y cycles

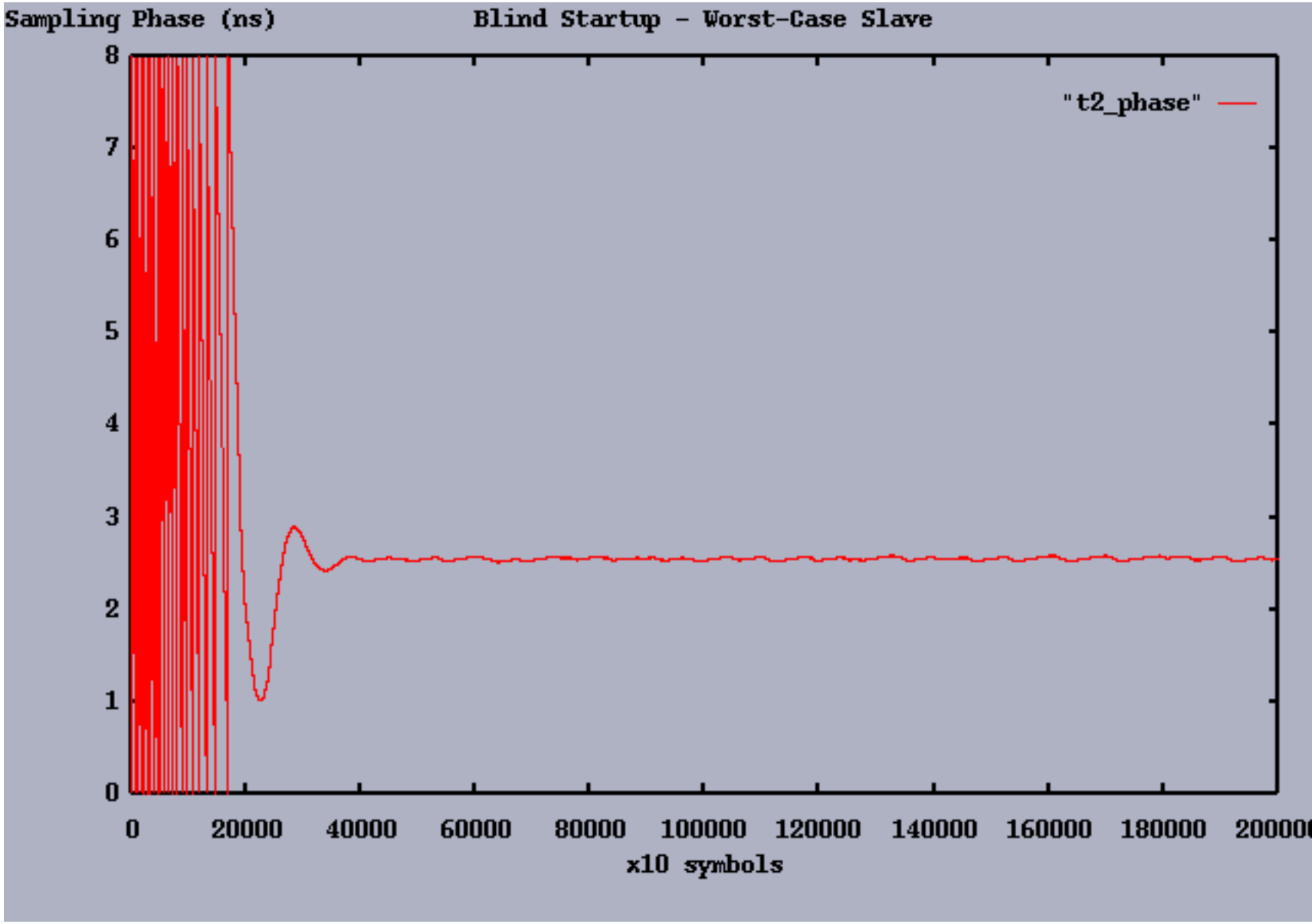
  Y=32 symbol periods

- Joint updates enabled when MSE < -12dB

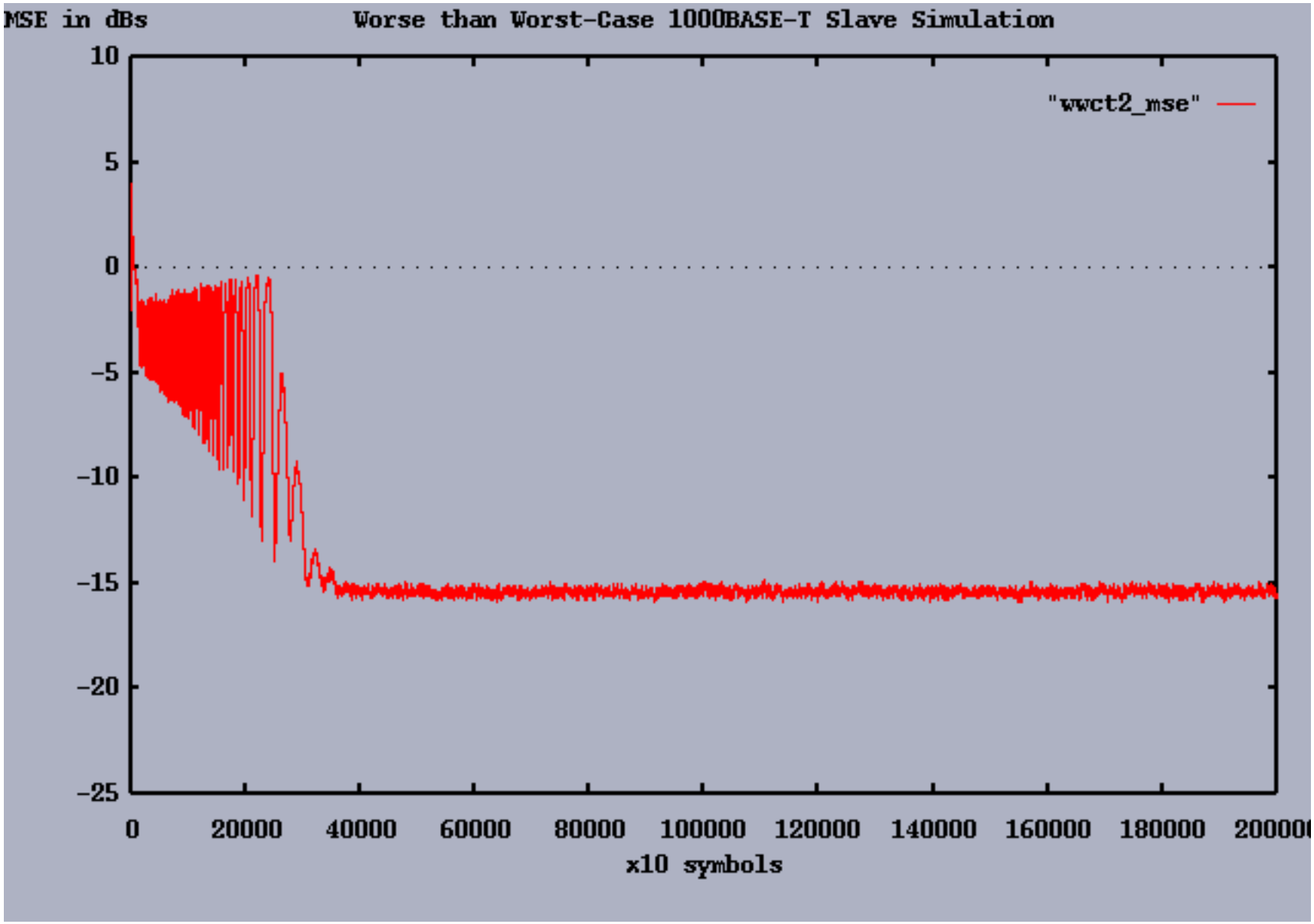
LEVEL ONE

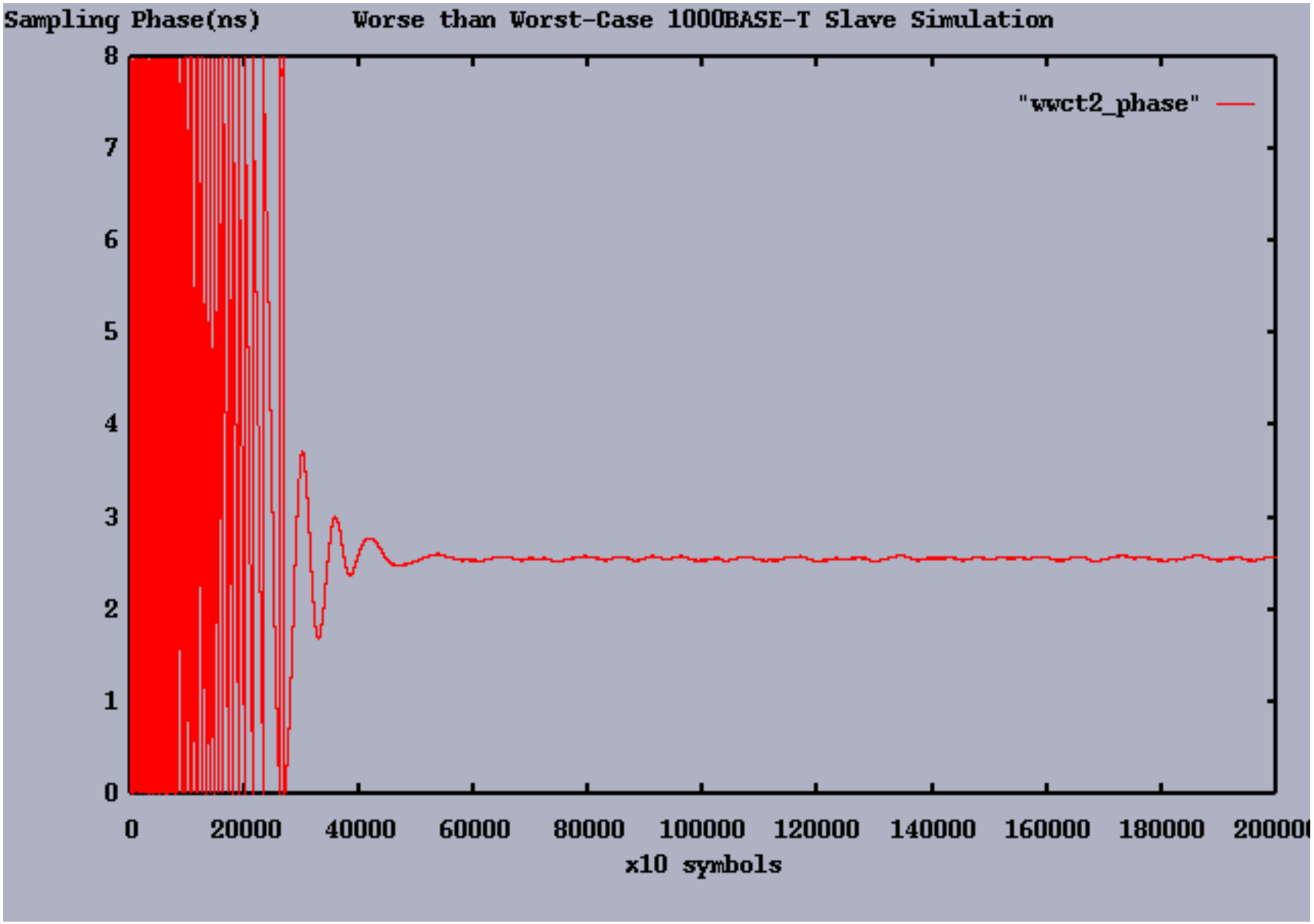

MSE in dBs
Blind Startup - Worst-Case Slave
"t2_mse"
5
0
-5
-10
-15
-20
-25
0
20000
40000
60000
80000
100000
120000
140000
160000
180000
x10 symbols

LEVEL ONE


Sampling Phase (ns)
Blind Startup - Worst-Case Slave
"t2_phase"
8
7
6
5
4
3
2
1
0
0
20000
40000
60000
80000
100000
120000
140000
160000
180000
x10 symbols

LEVEL ONE


MSE in dBs
Worse than Worst-Case 1000BASE-T Slave Simulation
"wwct2_mse"
10
5
0
-5
-10
-15
-20
-25
0
20000
40000
60000
80000
100000
120000
140000
160000
180000
x10 symbols


Sampling Phase(ns)
Worse than Worst-Case 1000BASE-T Slave Simulation
"wwct2_phase"
8
7
6
5
4
3
2
1
0
0
20000
40000
60000
80000
100000
120000
140000
160000
180000
x10 symbols

Sequenced Startup Protocol

- Delay Transmit Start for Slave PHY
  Slave acquires frequency in the absence of Echo
  Eases Slave Frequency Acquisition

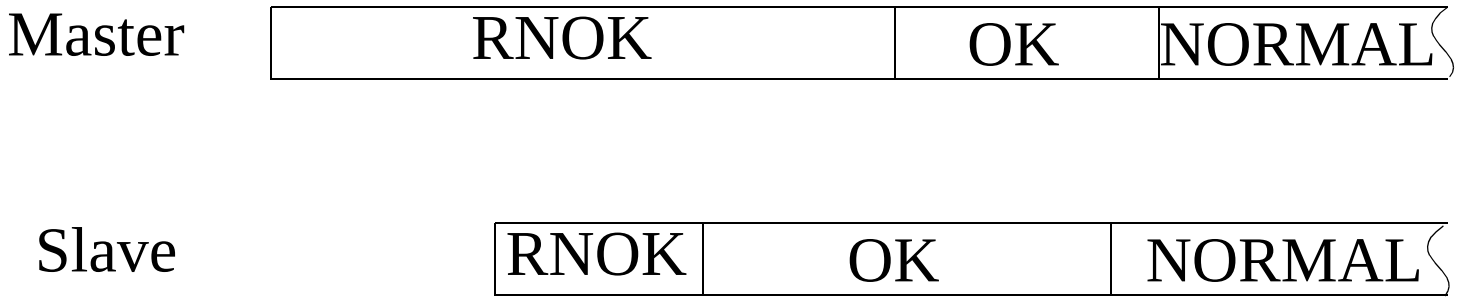
- Use 2-level signalling during tx_mode=SEND_I
  Improves initial BER by 6dB

- Guarantees that Master PHY receives signal at correct frequency
- Used in HDSL 2B1Q systems
  operates over 4km copper wiring in full duplex mode
  Signal-to-Echo ratio ~30dB worse than in 1000BASE-T

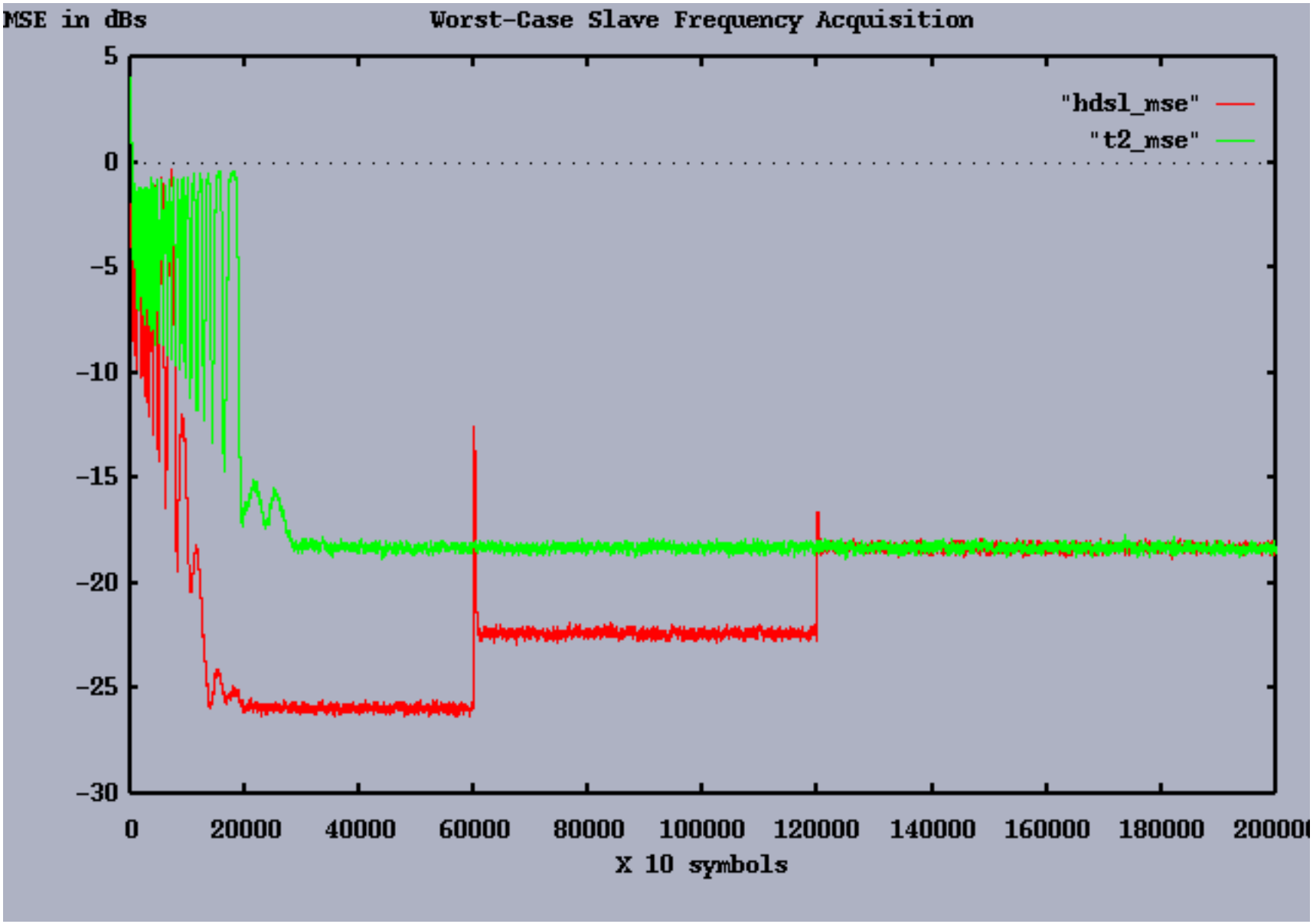
LEVEL ONE

Sequenced Startup Protocol - 1000BASE-T version

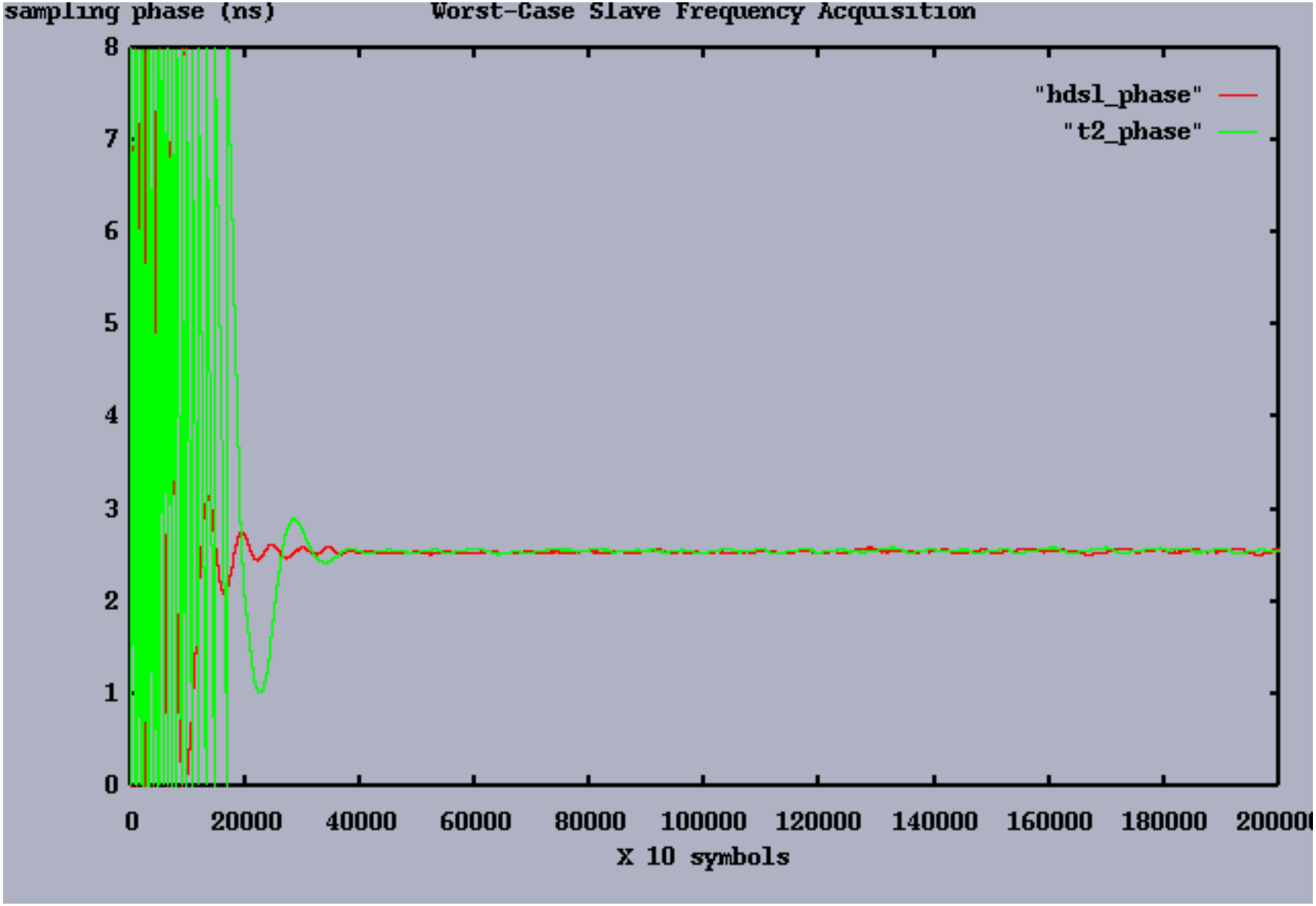
- 2-level RNOK/OK Idle Signalling during tx_mode=SEND_I

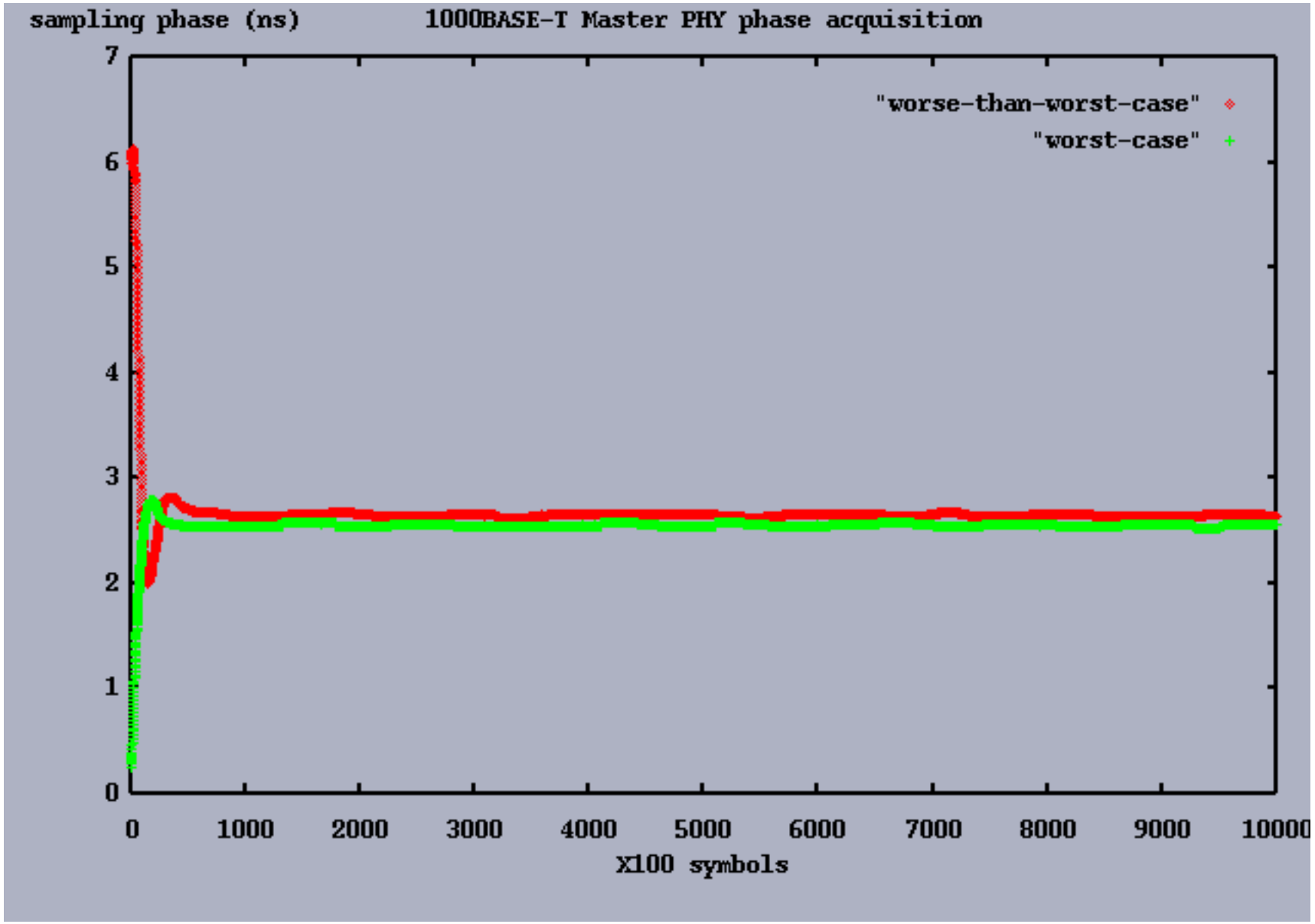


- Slave converges first, then Master.


MSE in dBs
Worst-Case Slave Frequency Acquisition
"hdsl_mse"
"t2_mse"
5
0
-5
-10
-15
-20
-25
-30
0
20000
40000
60000
80000
100000
120000
140000
160000
180000
X 10 symbols

LEVEL ONE


sampling phase (ns)
Worst-Case Slave Frequency Acquisition
"hdsl_phase"
"t2_phase"
8
7
6
5
4
3
2
1
0
0
20000
40000
60000
80000
100000
120000
140000
160000
180000
X 10 symbols


sampling phase (ns)
1000BASE-T Master PHY phase acquisition
"worse-than-worst-case"
"worst-case"
7
6
5
4
3
2
1
0
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
X100 symbols

LEVEL ONE

Worse-than-Worst-Case Simulations

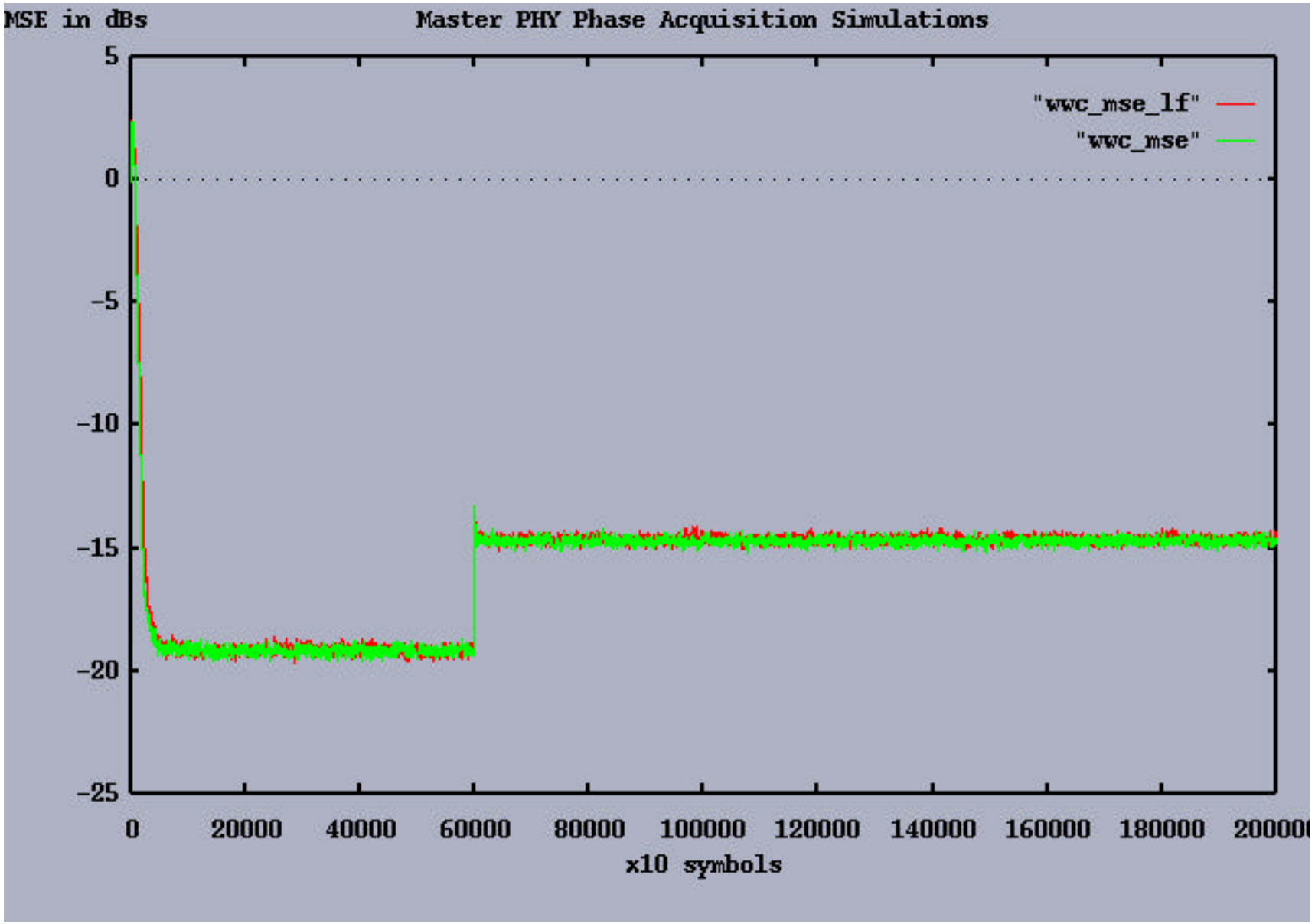
- WWC Environment

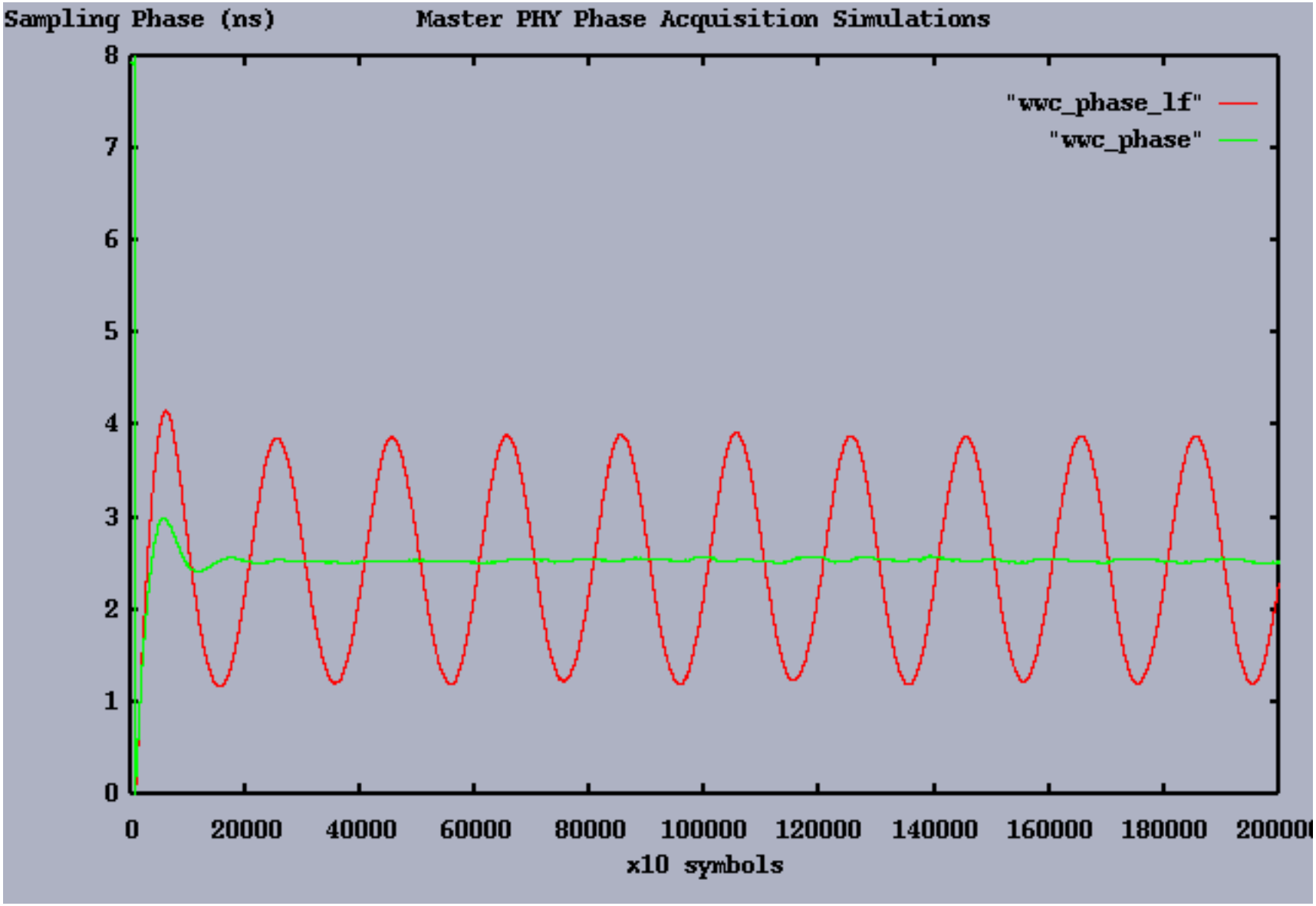
  BRC measured channel/NEXT models
  BRC echo model scaled up by 6dB
  100mV ptp sinusoidal interferer added
  Transmit/Receive Filtering as in Matlab code
  3dB design point used

- WWC_LF Environment

  BRC measure channel/NEXT models
  BRC echo model scaled up by 6dB
  100mV ptp sinusoidal interferer added
  Transmit/Receive filtering as in Matlab code
  3dB design point used
  2.4ns ptp jitter added on receive clock

LEVEL ONE


MSE in dBs
Master PHY Phase Acquisition Simulations
"wwc_mse_lf"
"wwc_mse"
5
0
-5
-10
-15
-20
-25
0
20000
40000
60000
80000
100000
120000
140000
160000
180000
x10 symbols


Sampling Phase (ns)
Master PHY Phase Acquisition Simulations
"wwc_phase_lf"
"wwc_phase"
8
7
6
5
4
3
2
1
0
0
20000
40000
60000
80000
100000
120000
140000
160000
180000
x10 symbols

LEVEL ONE

Conclusions

- Startup Protocol is not needed for 1000BASE-T since blind start-tup works reliably even under worse-than-worst-case conditions
- Sequenced Startup Protocol eases startup problem considerably
  not a theoretical approach
  field-tested protocol used in HDSL under 30dB worse Signal-to-Echo ratio conditions
- Risk-free sequenced startup protocol for 1000BASE-T