GMII Electrical Specification Options

DC Specifications

Mandatory - Communication between the transmitter and receiver can not occur at any bit rate without DC specifications.

AC Specifications

OPTION 1: Use the conventional approach.

**Specify one or two DC potentials at which at which all AC timing measurements are made,
specify receiving register minimum setup and hold times,
perhaps specify driver minimum and maximum clock to output delays and
model the effect of trace and receiver input capacitance on the driver as a lumped capacitor.**

Advantage - Simple

Disadvantages -

PCB trace length limited to avoid transmission line effects (limited to about 1.5 inches for 0.50 ns 10%-90% risetime and FR4 stripline).

No support for transmission line knowledgeable designers wanting to use longer traces (no assurance of adequate drive strength to insure first incident wave switching).

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OPTION 2: **Pick a topology (such as point to point),**
a minimum pcb trace impedance (such as 50 Ohms +/- 15%),
a maximum pcb trace length and
a termination technique (such as series/source termination) and
specify the driver output characteristics.

Advantages -

It insures correct operation with transmission lines for one topology.

It permits correct operation with transmission lines whose impedance is greater than the minimum.

Disadvantages -

Unnecessarily restrictive in terms of techniques used and topologies supported.

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OPTION 3: **Specify a standard GMII receiver input equivalent circuit,**
define a "GMII Interoperability Interface" at the GMII receiver input pin,
specify a "GMII Receiver Input Potential Template" that must be complied with at the input of all GMII receivers,
specify a basic transmission line topology that all GMII drivers must support,
let each vendor select the GMII driver characteristics and termination scheme to comply with the GMII Receiver Input Potential Template for the basic transmission line topology and
allow each vendor to support other transmission line topologies subject to the requirement that the input signal to each GMII receiver must comply with the GMII Receiver Input Signal Template.

Advantages -

Insures minimum support for transmission lines.
Allows vendors flexibility in how they support the basic topology.
Allows vendors flexibility in supporting other transmission line topologies.

Disadvantages -

Minimal

Challenges

Model of the GMII Receiver input circuit.
Effect of the GMII Receiver input circuit on the input potential waveform.

Proposed GMII Electrical Specification Objectives

Implementable with either 2.5 Volt or 3.3 Volt I/O pads

Compatible with 10 bit SerDes electrical specifications when implemented with 3.3 Volt I/O pads

Support point to point connections with PCB traces up to 6 inches in length and a minimum trace impedance of 50 Ohms +/- 15%

Specify the AC input signal to GMII receivers.

Do not specify the GMII driver AC characteristics

Do not specify the termination technique

Do not preclude other GMII interconnect topologies

Simulations

Frequency domain (Fourier) techniques are used which requires linear components

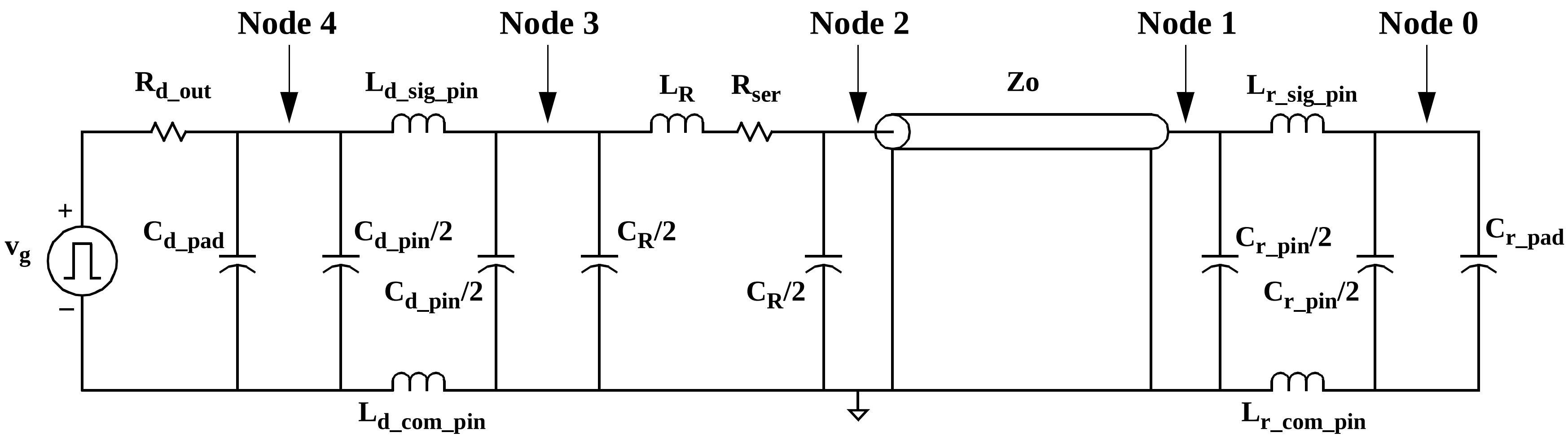
The driver model has constant output resistance.

This is not accurate for a driver with nonlinear output characteristics. But it is a reasonable approximation when source termination is used and the values of the series termination resistor is much greater than the driver output resistance.

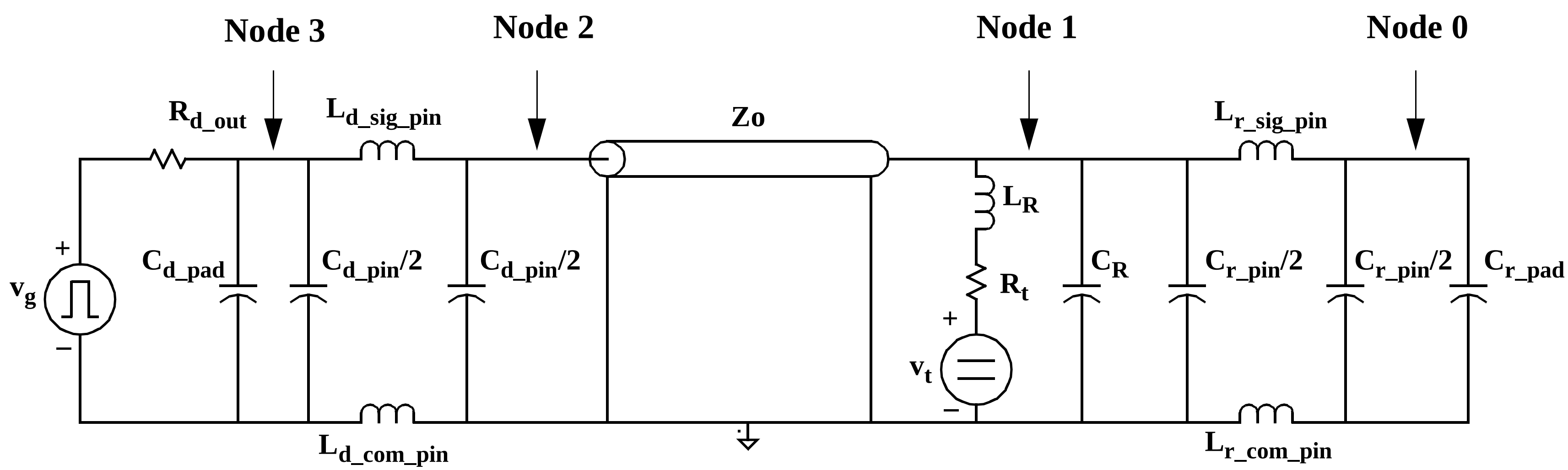
The transmission line model used is for stripline with

a dc resistance of 0.1006 Ohms per inch (5 mil wide pcb trace on 1 oz. copper),
a skin effect corner frequency of 7.42 MHz,
a dielectric constant of 4.22 at 1.0 MHz and that decreases 0.12 per frequency decade
a dielectric Dissipation Factor of 0.024

Simulation Model - Source (Series) Termination



Simulation Model - End (Parallel) Termination



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Examples of Transmission Line behavior for

a driver output resistances of 2.0*Zo and 0.5*Zo

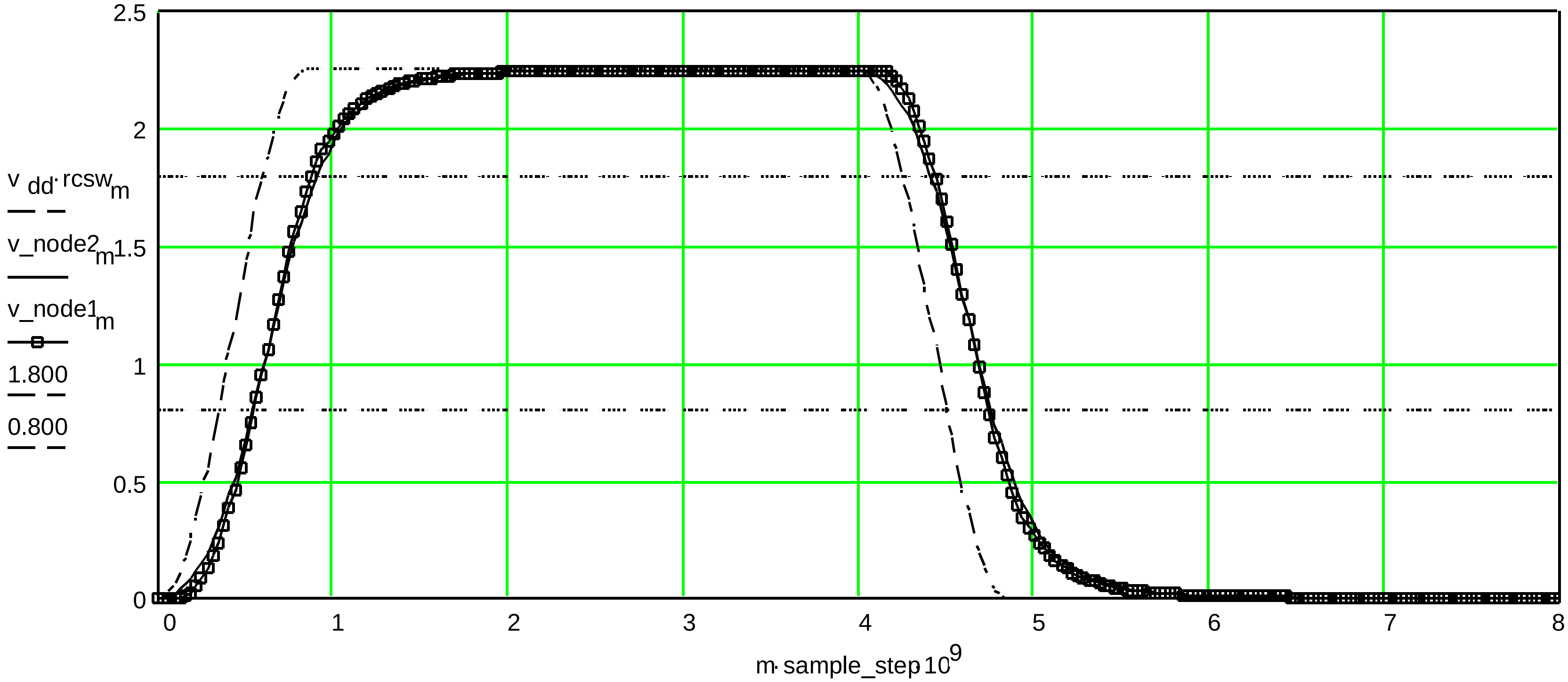
stripline pcb trace lengths of 0.75, 1.5, 3.0 and 6.0 inches

Note that

The output resistance of the driver functions as a mismatched source/series termination in these examples.

The output drive of a CMOS driver can vary at least 3:1 over supply potential, temperature and process variation.

Underdrive: R_{d_out} = 2*Zo



v_{dd} = 2.25

rise_time = $5 \cdot 10^{-10}$

R_{d_out} = 100

C_{d_pad} = $1 \cdot 10^{-15}$

C_{d_pin} = $1 \cdot 10^{-15}$

$L_{d\_sig\_pin}$ = $1 \cdot 10^{-12}$

$L_{d\_com\_pin}$ = $1 \cdot 10^{-12}$

R_{ser} = 0

C_R = $1 \cdot 10^{-15}$

L_R = $1 \cdot 10^{-12}$

Z_o = 50

line_length_inch = 0.75

one_way_delay_ns = 0.125

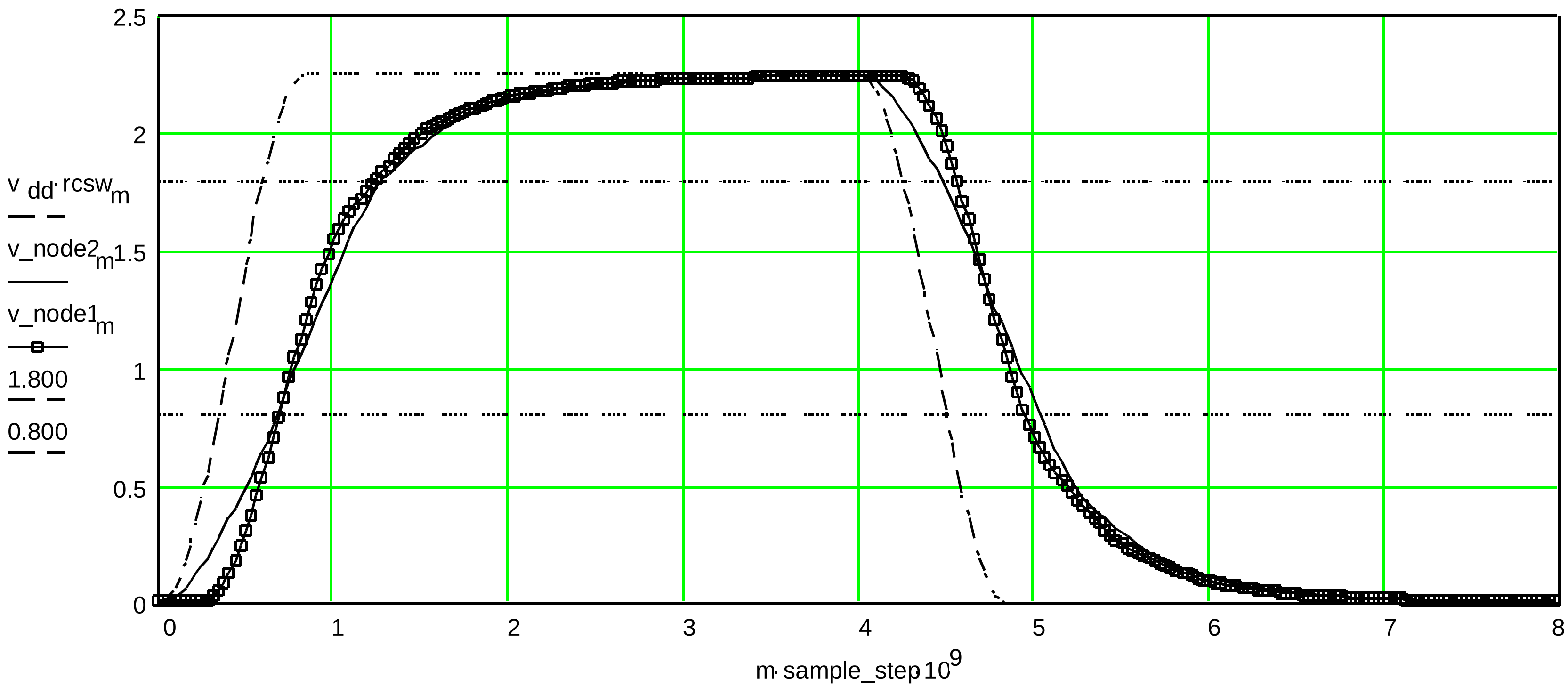
C_{r_pin} = $1 \cdot 10^{-15}$

C_{r_pad} = $1 \cdot 10^{-15}$

$L_{r\_sig\_pin}$ = $1 \cdot 10^{-12}$

$L_{r\_com\_pin}$ = $1 \cdot 10^{-12}$

Underdrive: R_{d_out} = 2*Zo



$v_{dd} = 2.25$

$rise\_time = 5 \cdot 10^{-10}$

$R_{d\_out} = 100$

$C_{d\_pad} = 1 \cdot 10^{-15}$

$C_{d\_pin} = 1 \cdot 10^{-15}$

$L_{d\_sig\_pin} = 1 \cdot 10^{-12}$

$L_{d\_com\_pin} = 1 \cdot 10^{-12}$

$R_{ser} = 0$

$C_R = 1 \cdot 10^{-15}$

$L_R = 1 \cdot 10^{-12}$

$Z_o = 50$

$line\_length\_inch = 1.5$

$one\_way\_delay\_ns = 0.25$

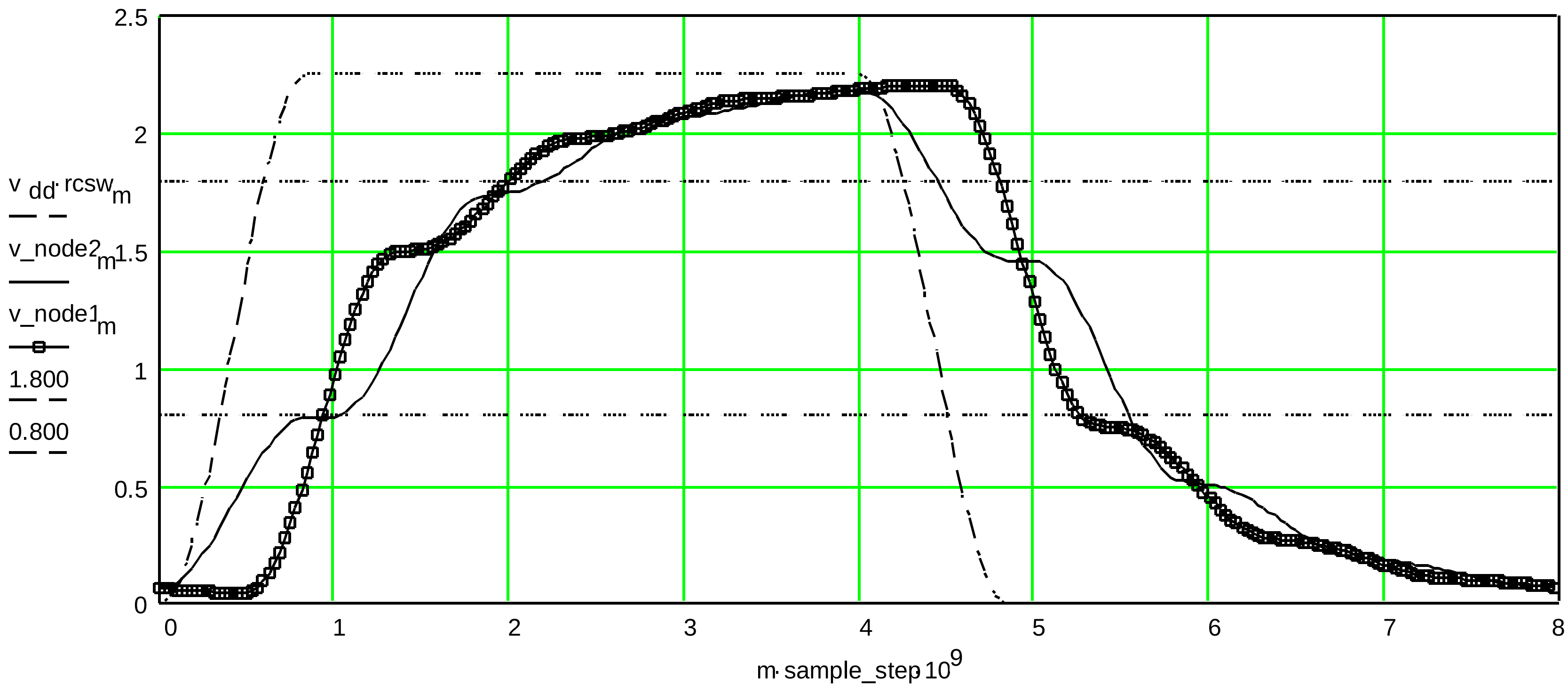
$C_{r\_pin} = 1 \cdot 10^{-15}$

$C_{r\_pad} = 1 \cdot 10^{-15}$

$L_{r\_sig\_pin} = 1 \cdot 10^{-12}$

$L_{r\_com\_pin} = 1 \cdot 10^{-12}$

Underdrive: R_{d_out} = 2*Zo



$v_{dd} = 2.25$

$rise\_time = 5 \cdot 10^{-10}$

$R_{d\_out} = 100$

$C_{d\_pad} = 1 \cdot 10^{-15}$

$C_{d\_pin} = 1 \cdot 10^{-15}$

$L_{d\_sig\_pin} = 1 \cdot 10^{-12}$

$L_{d\_com\_pin} = 1 \cdot 10^{-12}$

$R_{ser} = 0$

$C_R = 1 \cdot 10^{-15}$

$L_R = 1 \cdot 10^{-12}$

$Z_o = 50$

$line\_length\_inch = 3$

$one\_way\_delay\_ns = 0.5001$

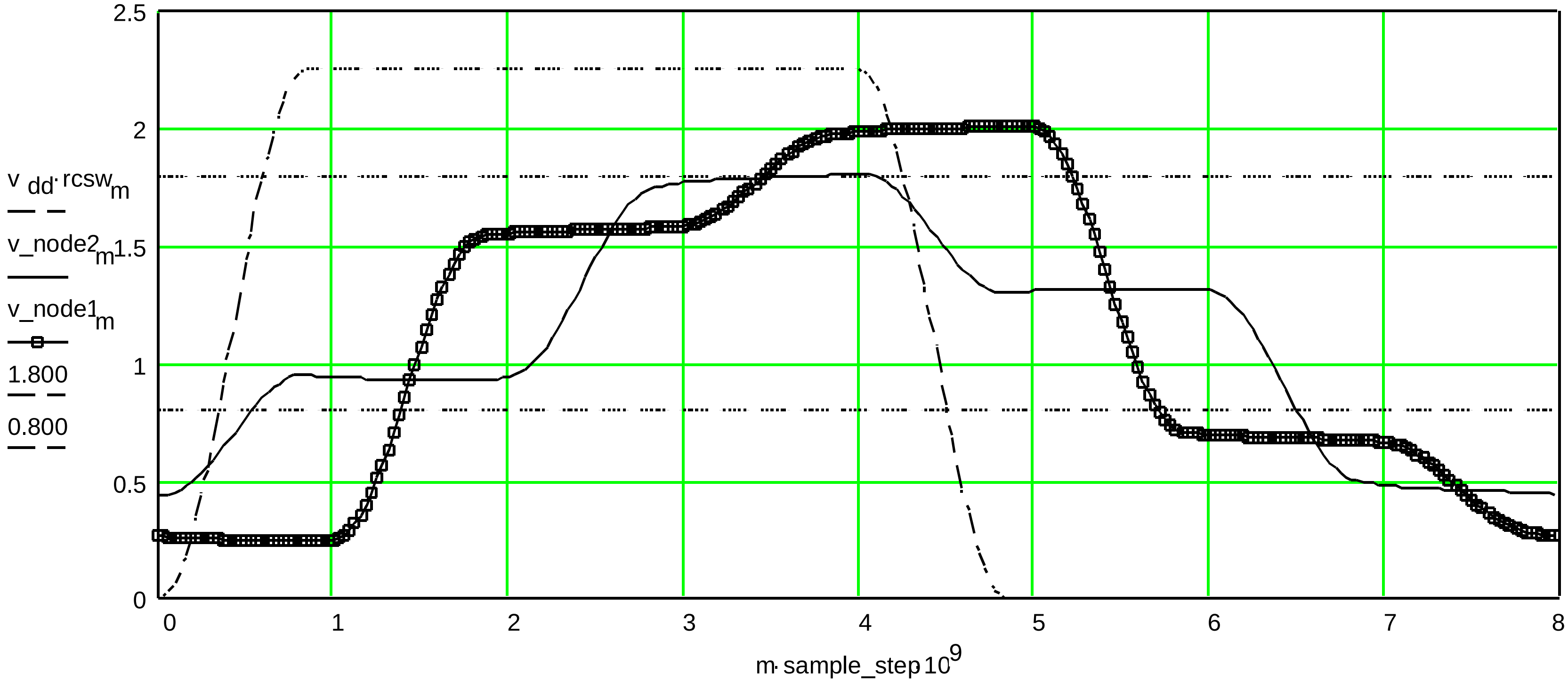
$C_{r\_pin} = 1 \cdot 10^{-15}$

$C_{r\_pad} = 1 \cdot 10^{-15}$

$L_{r\_sig\_pin} = 1 \cdot 10^{-12}$

$L_{r\_com\_pin} = 1 \cdot 10^{-12}$

Underdrive: $R_{d\_out} = 2*Zo$



$v_{dd} = 2.25$

$rise\_time = 5 \cdot 10^{-10}$

$R_{d\_out} = 100$

$C_{d\_pad} = 1 \cdot 10^{-15}$

$C_{d\_pin} = 1 \cdot 10^{-15}$

$L_{d\_sig\_pin} = 1 \cdot 10^{-12}$

$L_{d\_com\_pin} = 1 \cdot 10^{-12}$

$R_{ser} = 0$

$C_R = 1 \cdot 10^{-15}$

$L_R = 1 \cdot 10^{-12}$

$Z_o = 50$

$line\_length\_inch = 6$

$one\_way\_delay\_ns = 1.0001$

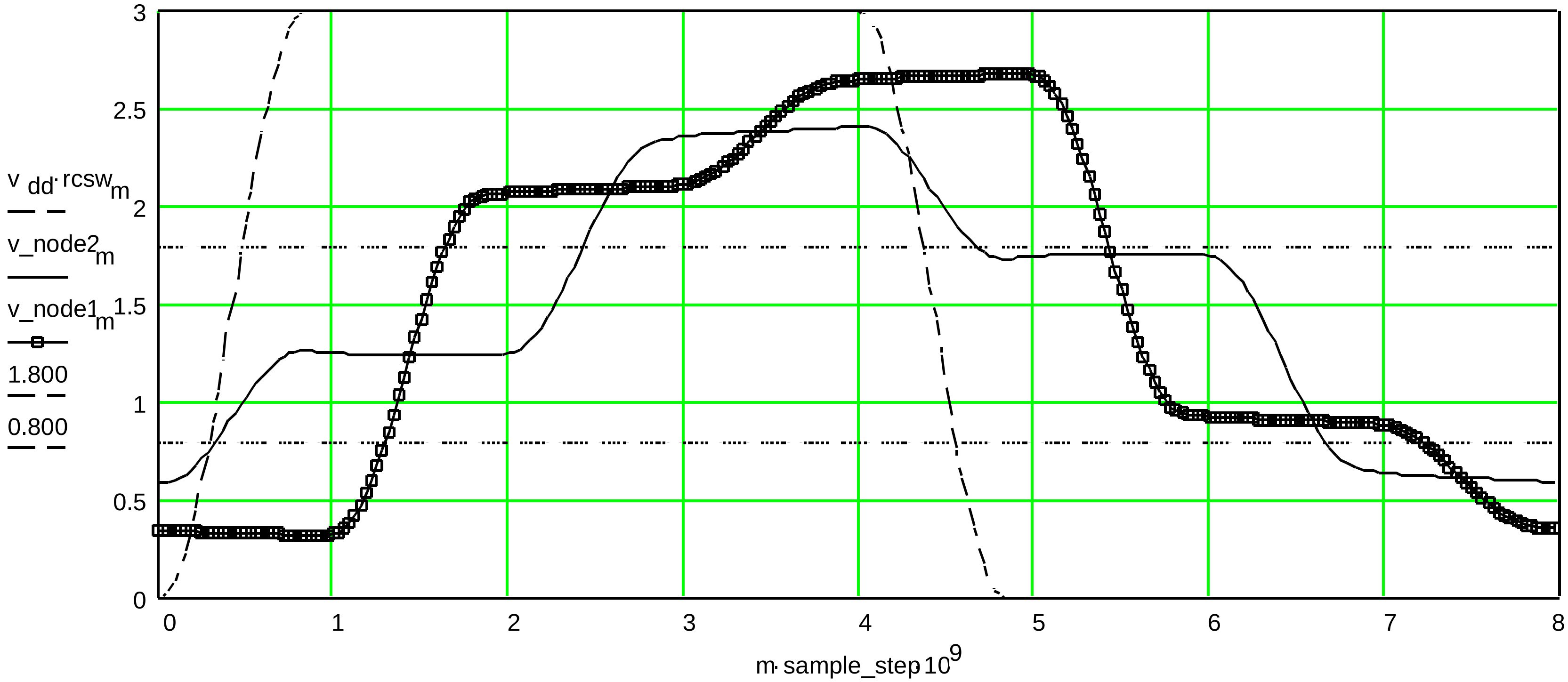
$C_{r\_pin} = 1 \cdot 10^{-15}$

$C_{r\_pad} = 1 \cdot 10^{-15}$

$L_{r\_sig\_pin} = 1 \cdot 10^{-12}$

$L_{r\_com\_pin} = 1 \cdot 10^{-12}$

Underdrive: R_{d_out} = 2*Zo



$v_{dd} = 3$

$rise\_time = 5 \cdot 10^{-10}$

$R_{d\_out} = 100$

$C_{d\_pad} = 1 \cdot 10^{-15}$

$C_{d\_pin} = 1 \cdot 10^{-15}$

$L_{d\_sig\_pin} = 1 \cdot 10^{-12}$

$L_{d\_com\_pin} = 1 \cdot 10^{-12}$

$R_{ser} = 0$

$C_R = 1 \cdot 10^{-15}$

$L_R = 1 \cdot 10^{-12}$

$Z_o = 50$

line_length_inch = 6

one_way_delay_ns = 1.0001

$C_{r\_pin} = 1 \cdot 10^{-15}$

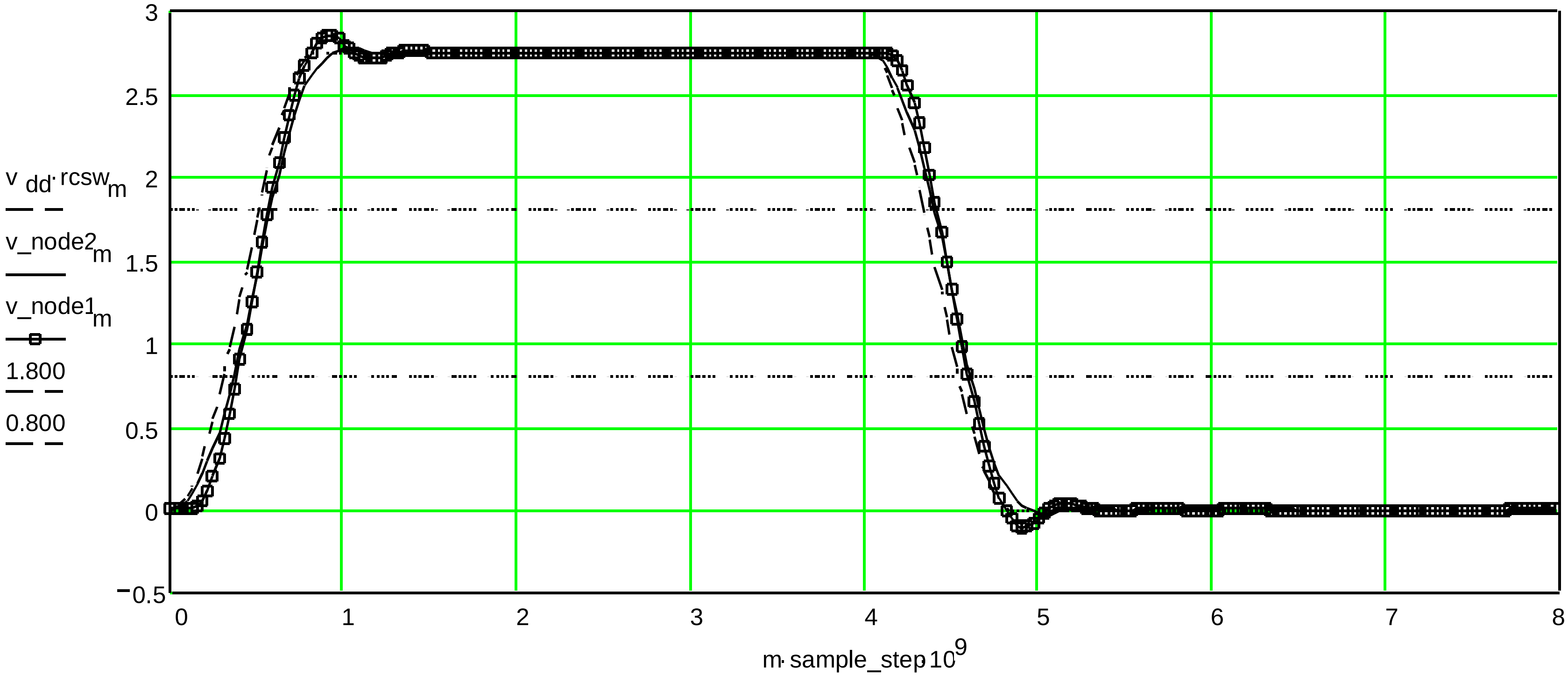
$C_{r\_pad} = 1 \cdot 10^{-15}$

$L_{r\_sig\_pin} = 1 \cdot 10^{-12}$

$L_{r\_com\_pin} = 1 \cdot 10^{-12}$

Increasing V_{dd} solves a problem on the rising edge but creates a problem on the falling edge

Overdrive: R_{d_out} = Zo/2



v_{dd} = 2.75

rise_time = $5 \cdot 10^{-10}$

R_{d_out} = 25

C_{d_pad} = $1 \cdot 10^{-15}$

C_{d_pin} = $1 \cdot 10^{-15}$

$L_{d\_sig\_pin}$ = $1 \cdot 10^{-12}$

$L_{d\_com\_pin}$ = $1 \cdot 10^{-12}$

R_{ser} = 0

C_R = $1 \cdot 10^{-15}$

L_R = $1 \cdot 10^{-12}$

Z_o = 50

line_length_inch = 0.75

one_way_delay_ns = 0.125

C_{r_pin} = $1 \cdot 10^{-15}$

C_{r_pad} = $1 \cdot 10^{-15}$

$L_{r\_sig\_pin}$ = $1 \cdot 10^{-12}$

$L_{r\_com\_pin}$ = $1 \cdot 10^{-12}$

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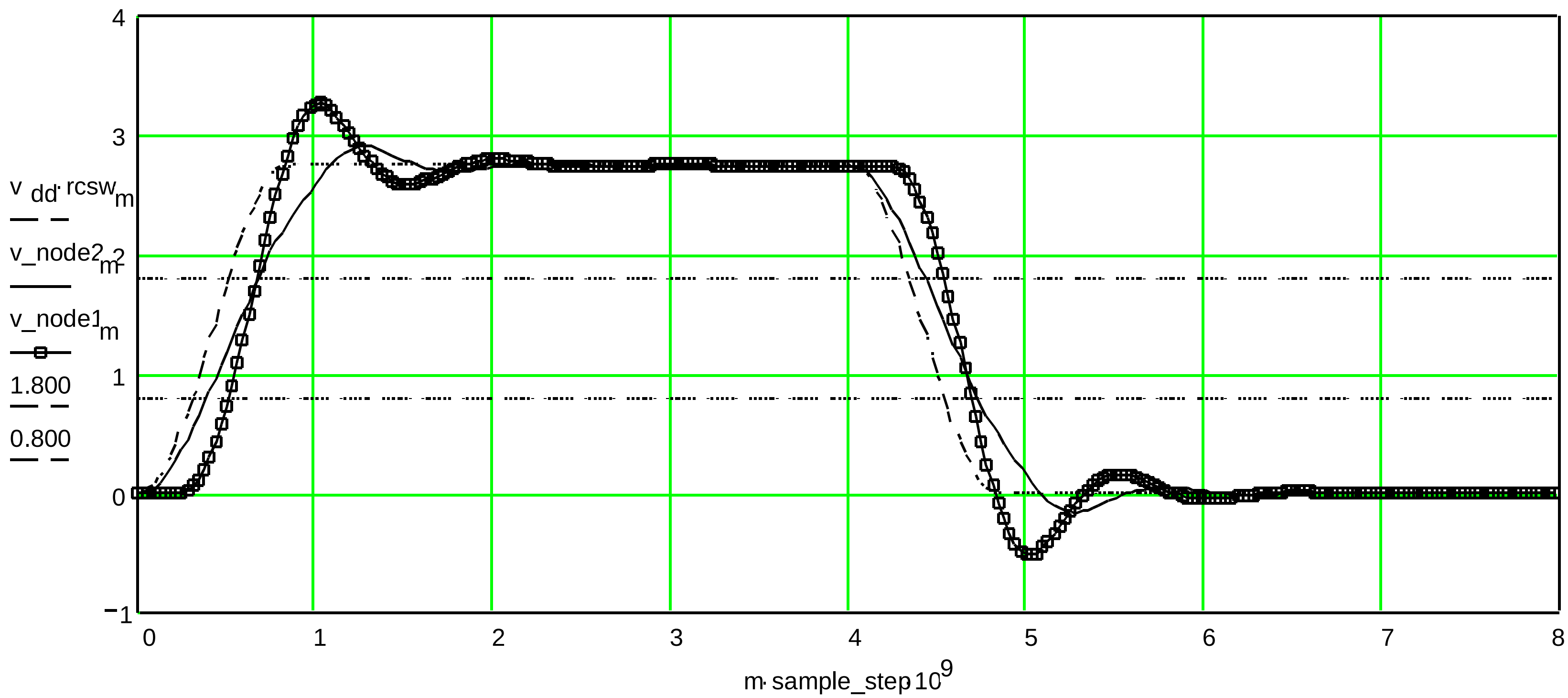
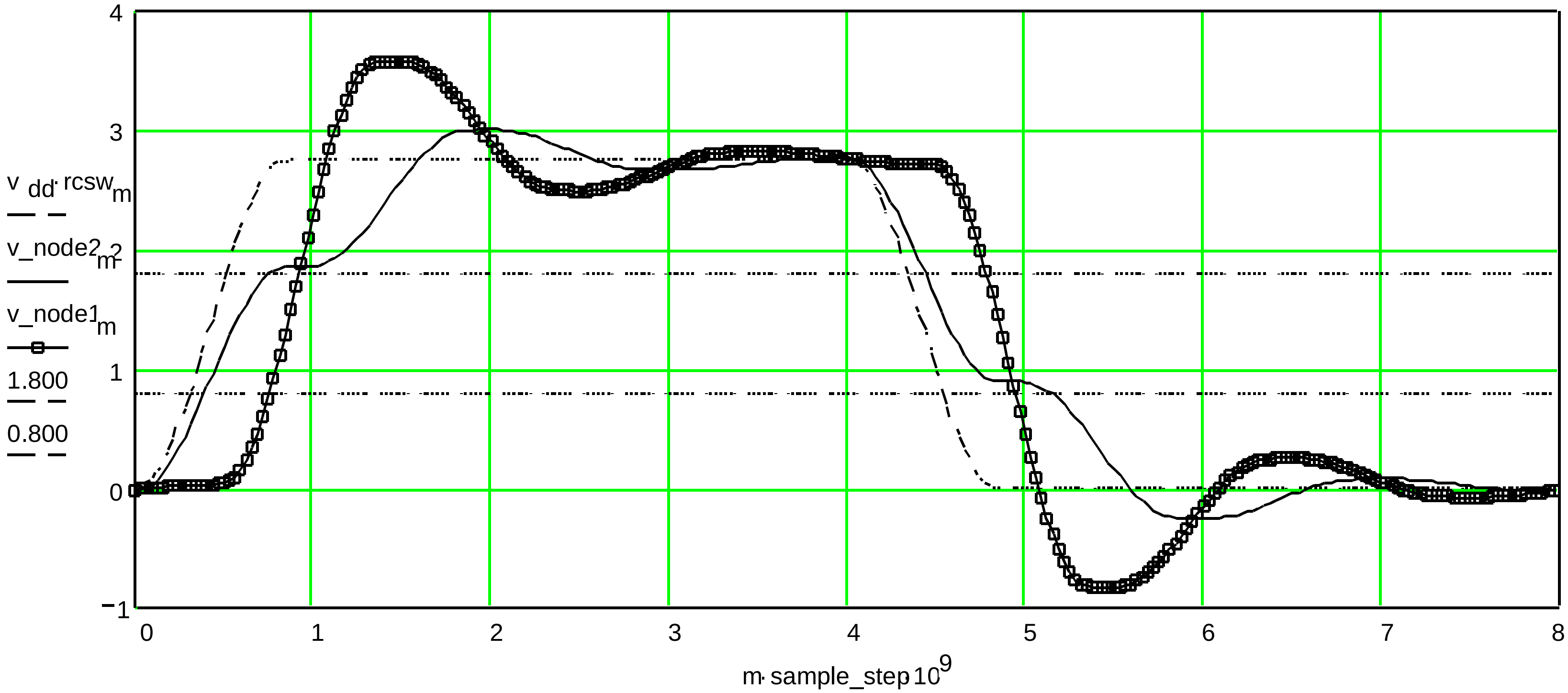
Overdrive: R_{d_out} = Zo/2



v_{dd} = 2.75	C_{d_pad} = $1 \cdot 10^{-15}$	R_{ser} = 0	Z_o = 50	C_{r_pin} = $1 \cdot 10^{-15}$
rise_time = $5 \cdot 10^{-10}$	C_{d_pin} = $1 \cdot 10^{-15}$	C_R = $1 \cdot 10^{-15}$	line_length_inch = 1.5	C_{r_pad} = $1 \cdot 10^{-15}$
R_{d_out} = 25	$L_{d\_sig\_pin}$ = $1 \cdot 10^{-12}$	L_R = $1 \cdot 10^{-12}$	one_way_delay_ns = 0.25	$L_{r\_sig\_pin}$ = $1 \cdot 10^{-12}$
	$L_{d\_com\_pin}$ = $1 \cdot 10^{-12}$			$L_{r\_com\_pin}$ = $1 \cdot 10^{-12}$

Overdrive: R_{d_out} = Zo/2



$v_{dd} = 2.75$

$rise\_time = 5 \cdot 10^{-10}$

$R_{d\_out} = 25$

$C_{d\_pad} = 1 \cdot 10^{-15}$

$C_{d\_pin} = 1 \cdot 10^{-15}$

$L_{d\_sig\_pin} = 1 \cdot 10^{-12}$

$L_{d\_com\_pin} = 1 \cdot 10^{-12}$

$R_{ser} = 0$

$C_R = 1 \cdot 10^{-15}$

$L_R = 1 \cdot 10^{-12}$

$Z_o = 50$

line_length_inch = 3

one_way_delay_ns = 0.5001

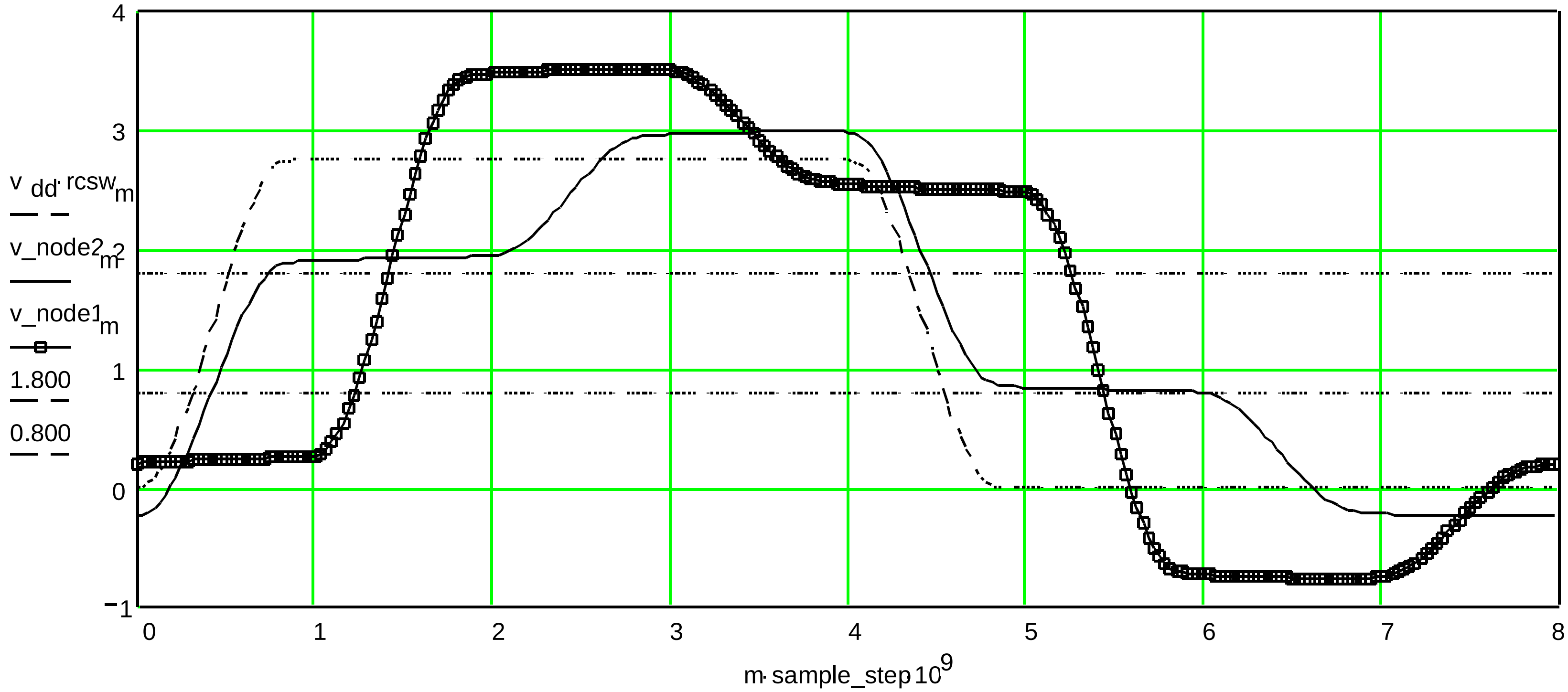
$C_{r\_pin} = 1 \cdot 10^{-15}$

$C_{r\_pad} = 1 \cdot 10^{-15}$

$L_{r\_sig\_pin} = 1 \cdot 10^{-12}$

$L_{r\_com\_pin} = 1 \cdot 10^{-12}$

Overdrive: R_{d_out} = Zo/2



$v_{dd} = 2.75$

$rise\_time = 5 \cdot 10^{-10}$

$R_{d\_out} = 25$

$C_{d\_pad} = 1 \cdot 10^{-15}$

$C_{d\_pin} = 1 \cdot 10^{-15}$

$L_{d\_sig\_pin} = 1 \cdot 10^{-12}$

$L_{d\_com\_pin} = 1 \cdot 10^{-12}$

$R_{ser} = 0$

$C_R = 1 \cdot 10^{-15}$

$L_R = 1 \cdot 10^{-12}$

$Z_o = 50$

$line\_length\_inch = 6$

$one\_way\_delay\_ns = 1.0001$

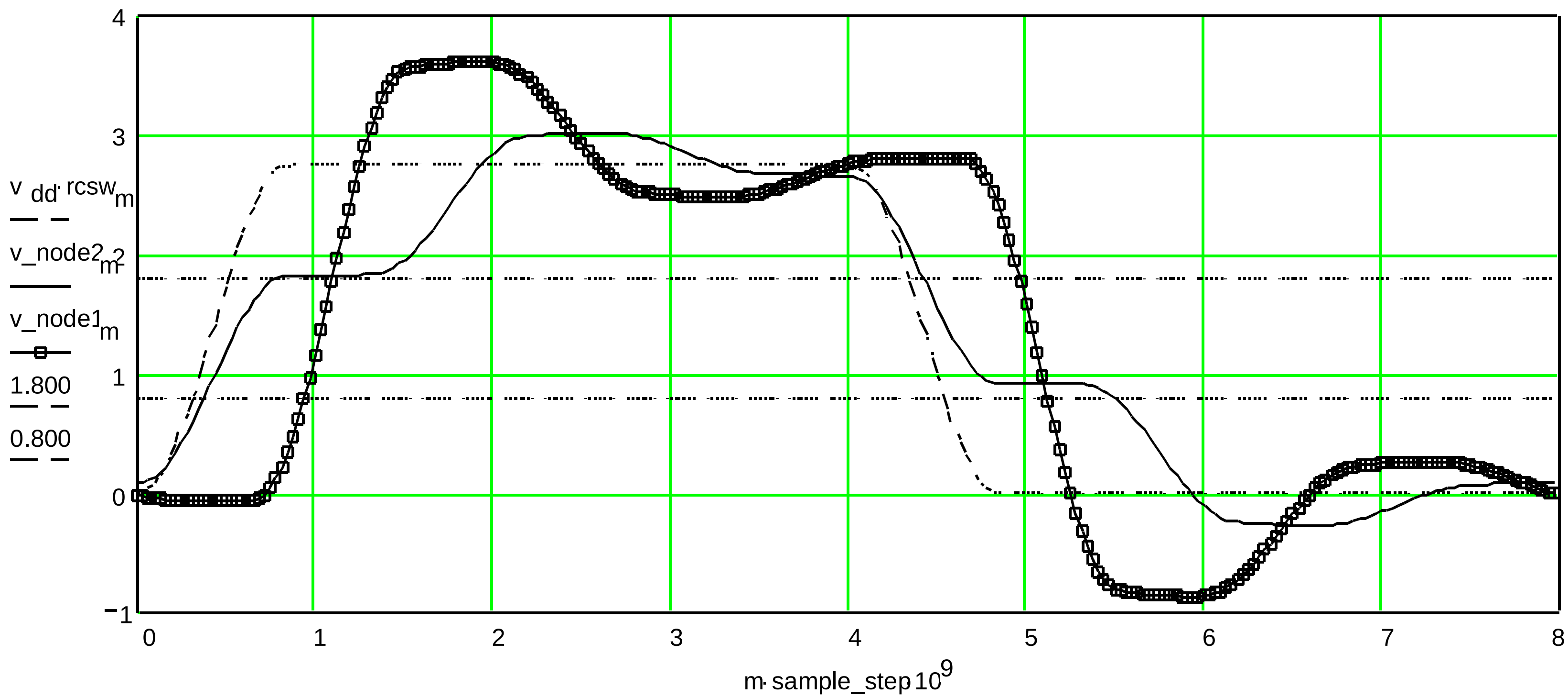
$C_{r\_pin} = 1 \cdot 10^{-15}$

$C_{r\_pad} = 1 \cdot 10^{-15}$

$L_{r\_sig\_pin} = 1 \cdot 10^{-12}$

$L_{r\_com\_pin} = 1 \cdot 10^{-12}$

Overdrive: R_{d_out} = Zo/2



$v_{dd} = 2.75$

$rise\_time = 5 \cdot 10^{-10}$

$R_{d\_out} = 25$

$C_{d\_pad} = 1 \cdot 10^{-15}$

$C_{d\_pin} = 1 \cdot 10^{-15}$

$L_{d\_sig\_pin} = 1 \cdot 10^{-12}$

$L_{d\_com\_pin} = 1 \cdot 10^{-12}$

$R_{ser} = 0$

$C_R = 1 \cdot 10^{-15}$

$L_R = 1 \cdot 10^{-12}$

$Z_o = 50$

$line\_length\_inch = 4$

$one\_way\_delay\_ns = 0.6667$

$C_{r\_pin} = 1 \cdot 10^{-15}$

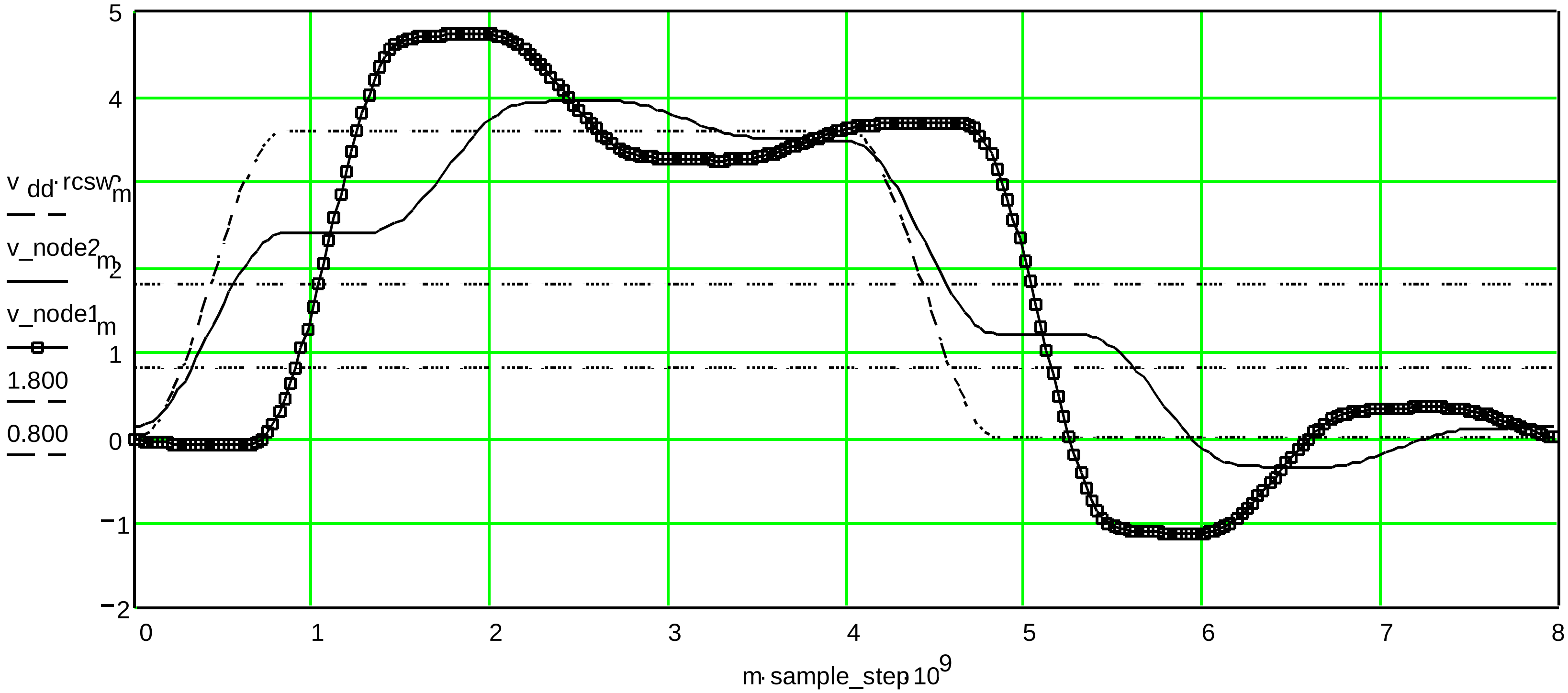
$C_{r\_pad} = 1 \cdot 10^{-15}$

$L_{r\_sig\_pin} = 1 \cdot 10^{-12}$

$L_{r\_com\_pin} = 1 \cdot 10^{-12}$

Ringing is greatest at 4 inches where the line has a weak resonance at 375 MHz

Overdrive: R_{d_out} = Zo/2



$v_{dd} = 3.6$

$rise\_time = 5 \cdot 10^{-10}$

$R_{d\_out} = 25$

$C_{d\_pad} = 1 \cdot 10^{-15}$

$C_{d\_pin} = 1 \cdot 10^{-15}$

$L_{d\_sig\_pin} = 1 \cdot 10^{-12}$

$L_{d\_com\_pin} = 1 \cdot 10^{-12}$

$R_{ser} = 0$

$C_{R} = 1 \cdot 10^{-15}$

$L_{R} = 1 \cdot 10^{-12}$

$Z_{o} = 50$

$line\_length\_inch = 4$

$one\_way\_delay\_ns = 0.6667$

$C_{r\_pin} = 1 \cdot 10^{-15}$

$C_{r\_pad} = 1 \cdot 10^{-15}$

$L_{r\_sig\_pin} = 1 \cdot 10^{-12}$

$L_{r\_com\_pin} = 1 \cdot 10^{-12}$

Overshoot is a problem for 3.3 Volt drivers, especially with 2.5 Volt receivers

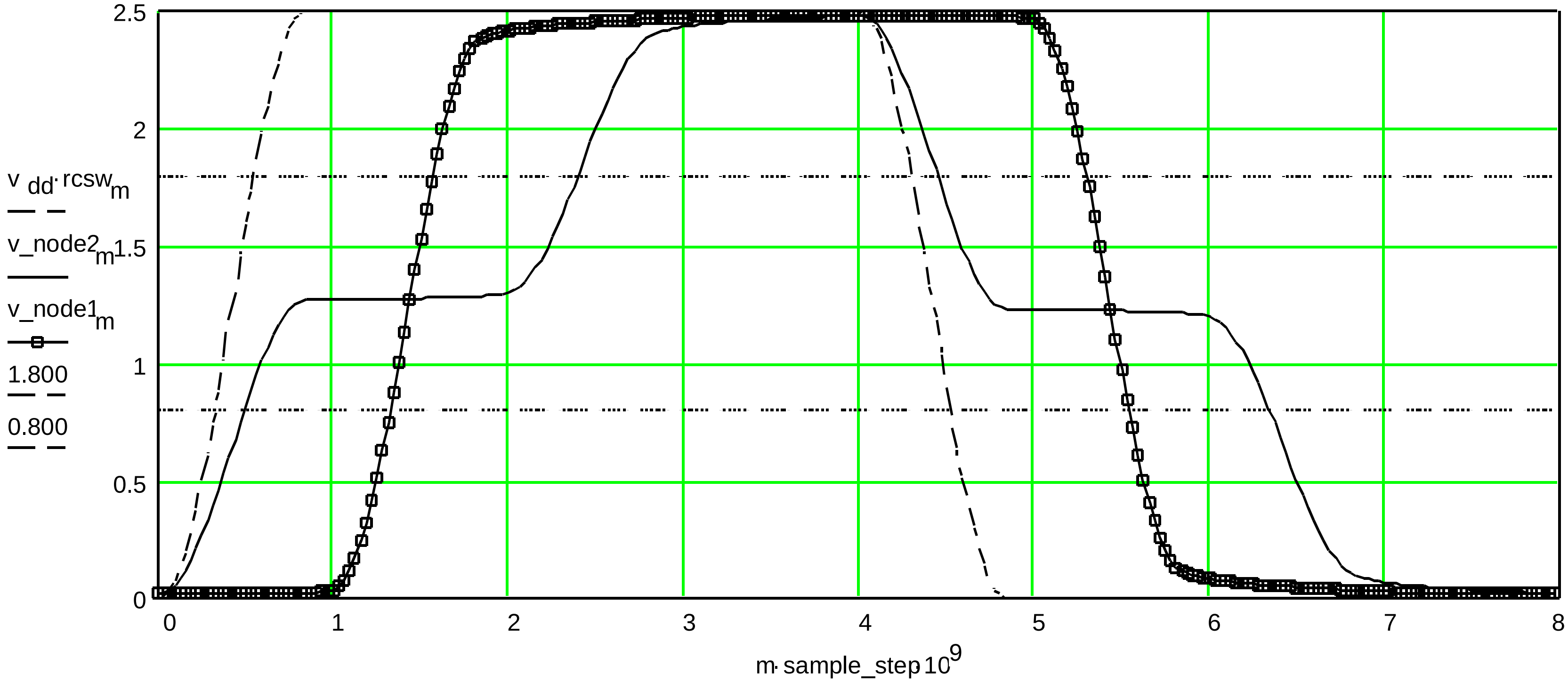
What are the effects of the GMII receiver input parasitics on source and end terminated lines?

Proposed values for input parasitics

Table 1:

Parameter	BGA	Lucent	National
Cr_pin	2.0 pF	4.0 pF	0.5 pF
Lr_sig_pin	6.0 nH	17.2 nH	10 nH
Lr_com_pin	2.0 nH	16.1 nH	10 nH
Cr_pad	2.0 pF	1.43 pF	4.5 pF

Source (Series) Termination



$v_{dd} = 2.5$

$rise\_time = 5 \cdot 10^{-10}$

$R_{d\_out} = 0$

$C_{d\_pad} = 1 \cdot 10^{-15}$

$C_{d\_pin} = 1 \cdot 10^{-15}$

$L_{d\_sig\_pin} = 1 \cdot 10^{-12}$

$L_{d\_com\_pin} = 1 \cdot 10^{-12}$

$R_{ser} = 50$

$C_R = 1 \cdot 10^{-15}$

$L_R = 1 \cdot 10^{-12}$

$Z_o = 50$

$line\_length\_inch = 6$

$one\_way\_delay\_ns = 1.0001$

$C_{r\_pin} = 1 \cdot 10^{-15}$

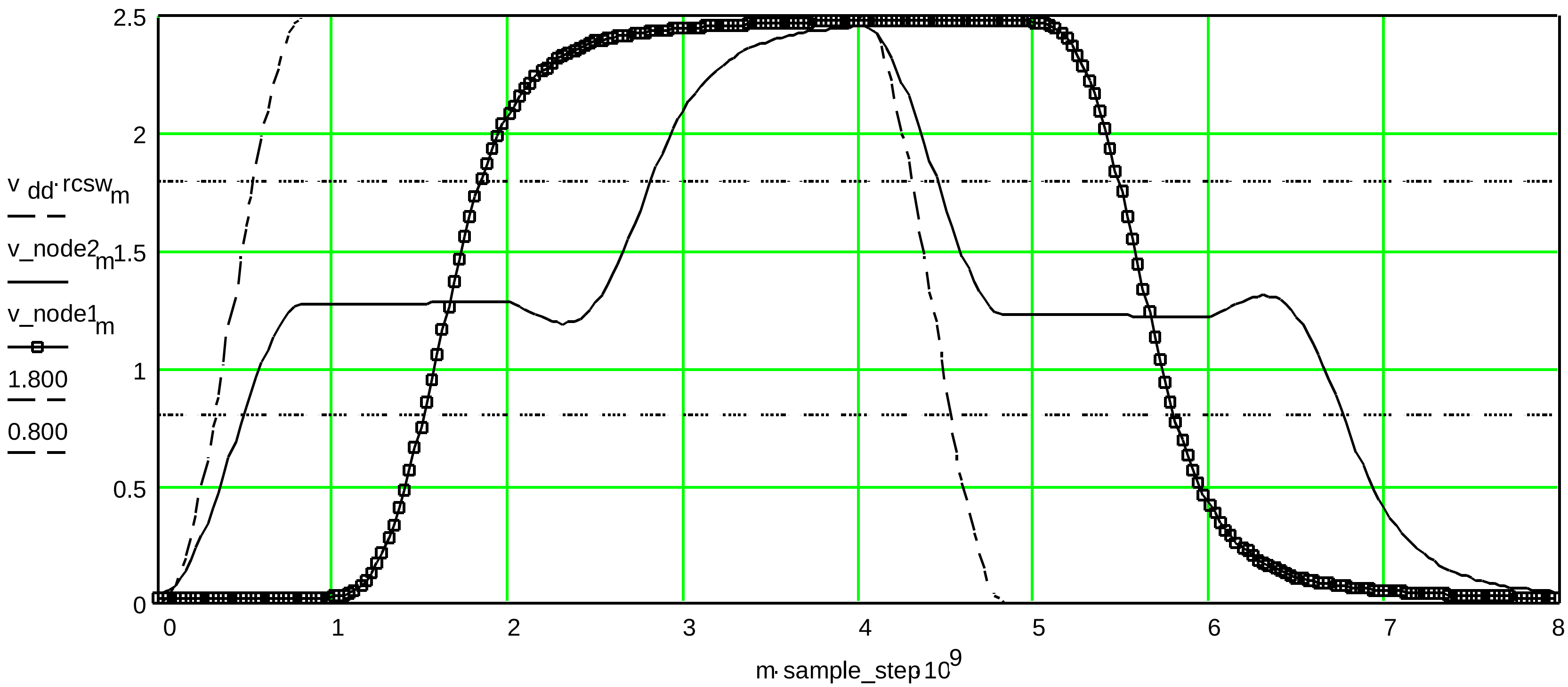
$C_{r\_pad} = 1 \cdot 10^{-15}$

$L_{r\_sig\_pin} = 1 \cdot 10^{-12}$

$L_{r\_com\_pin} = 1 \cdot 10^{-12}$

No GMII receiver loading

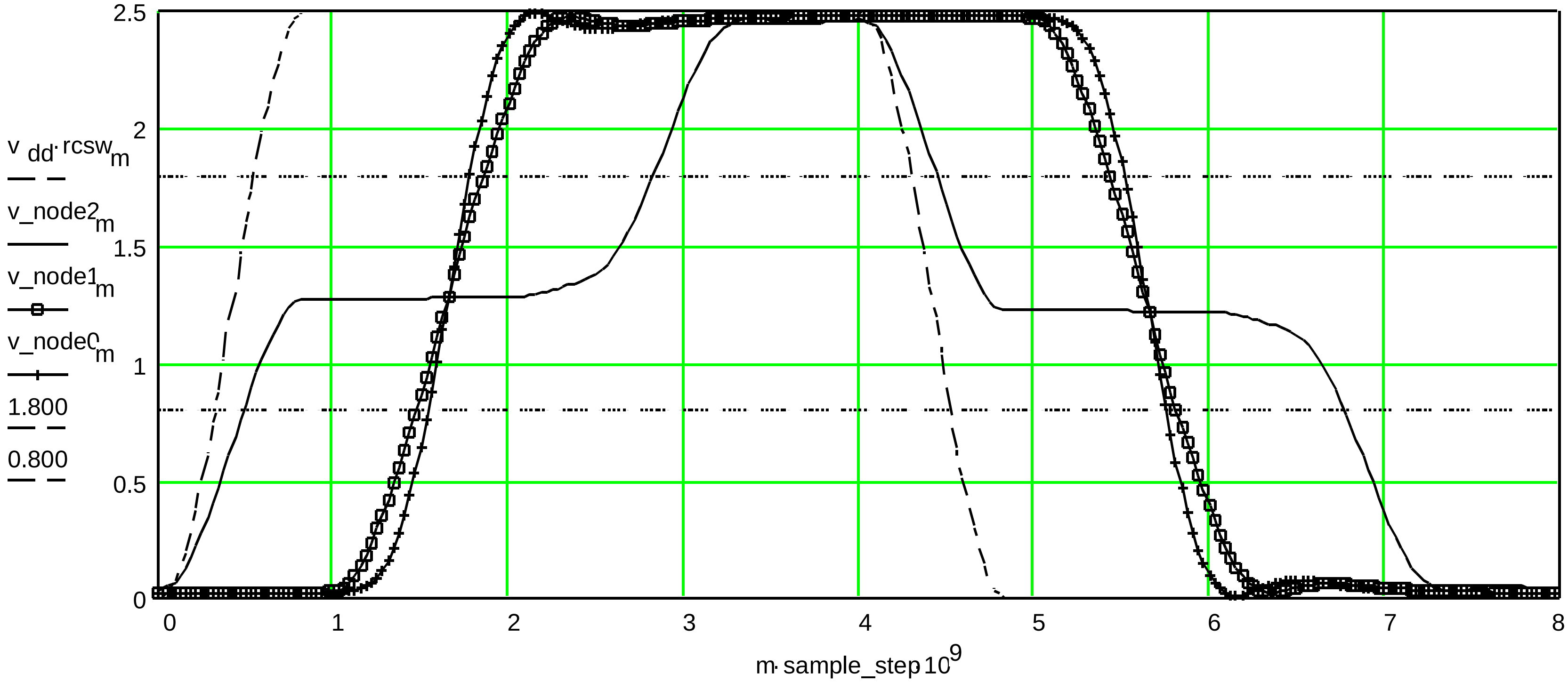
Source (Series) Termination



$v_{dd} = 2.5$	$C_{d\_pad} = 1 \cdot 10^{-15}$	$R_{ser} = 50$	$Z_o = 50$	$C_{r\_pin} = 2 \cdot 10^{-12}$
$rise\_time = 5 \cdot 10^{-10}$	$C_{d\_pin} = 1 \cdot 10^{-15}$	$C_R = 1 \cdot 10^{-15}$	line_length_inch = 6	$C_{r\_pad} = 3 \cdot 10^{-12}$
$R_{d\_out} = 0$	$L_{d\_sig\_pin} = 1 \cdot 10^{-12}$	$L_R = 1 \cdot 10^{-12}$	one_way_delay_ns = 1.0001	$L_{r\_sig\_pin} = 1 \cdot 10^{-12}$
	$L_{d\_com\_pin} = 1 \cdot 10^{-12}$			$L_{r\_com\_pin} = 1 \cdot 10^{-12}$

5 pF at the GMII receiver end of the line

Source (Series) Termination



$v_{dd} = 2.5$

$rise\_time = 5 \cdot 10^{-10}$

$R_{d\_out} = 0$

$C_{d\_pad} = 1 \cdot 10^{-15}$

$C_{d\_pin} = 1 \cdot 10^{-15}$

$L_{d\_sig\_pin} = 1 \cdot 10^{-12}$

$L_{d\_com\_pin} = 1 \cdot 10^{-12}$

$R_{ser} = 50$

$C_R = 1 \cdot 10^{-15}$

$L_R = 1 \cdot 10^{-12}$

$Z_o = 50$

line_length_inch = 6

one_way_delay_ns = 1.0001

$C_{r\_pin} = 2 \cdot 10^{-12}$

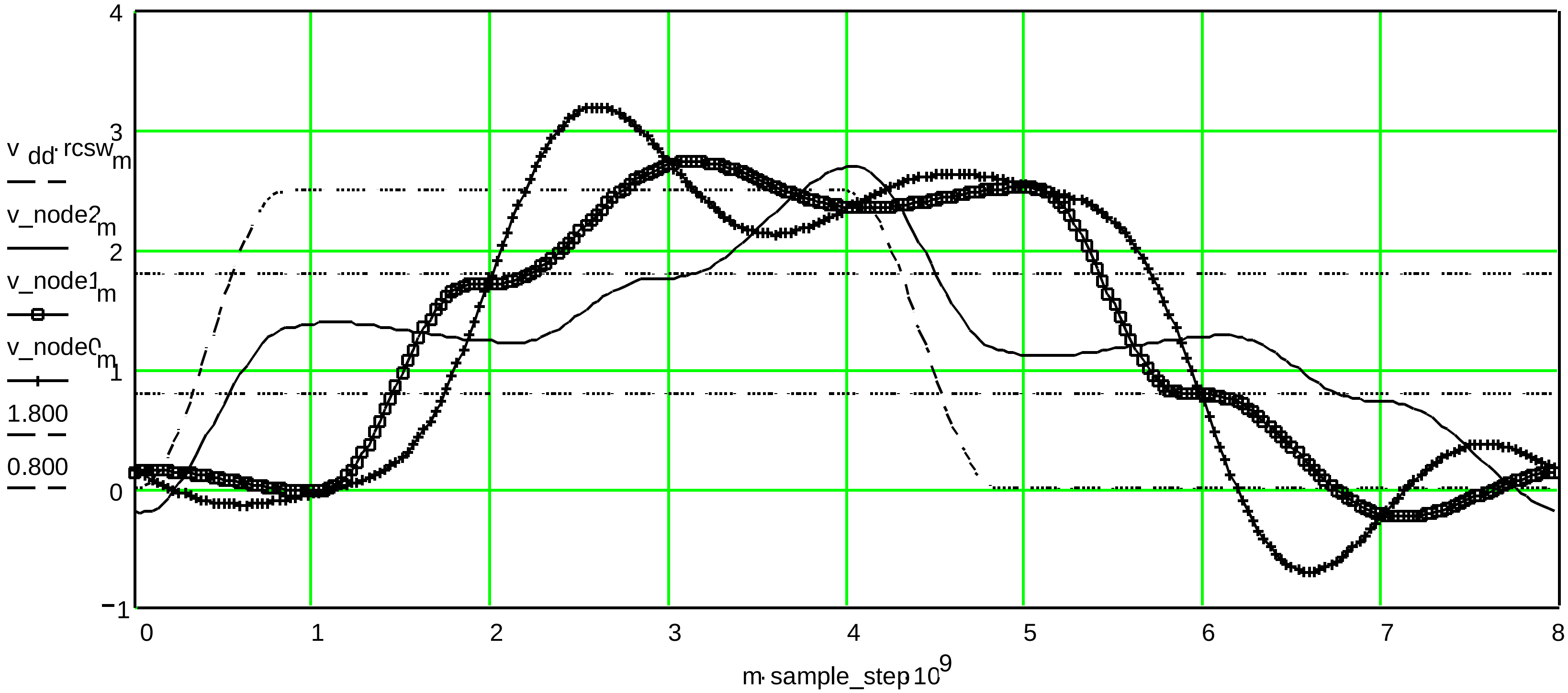
$C_{r\_pad} = 2 \cdot 10^{-12}$

$L_{r\_sig\_pin} = 6 \cdot 10^{-9}$

$L_{r\_com\_pin} = 2 \cdot 10^{-9}$

GMII receiver Pi network with BGA Values

Source (Series) Termination



$v_{dd} = 2.5$

$rise\_time = 5 \cdot 10^{-10}$

$R_{d\_out} = 0$

$C_{d\_pad} = 1 \cdot 10^{-15}$

$C_{d\_pin} = 1 \cdot 10^{-15}$

$L_{d\_sig\_pin} = 1 \cdot 10^{-12}$

$L_{d\_com\_pin} = 1 \cdot 10^{-12}$

$R_{ser} = 50$

$C_{R} = 1 \cdot 10^{-15}$

$L_{R} = 1 \cdot 10^{-12}$

$Z_{o} = 50$

$line\_length\_inch = 6$

$one\_way\_delay\_ns = 1.0001$

$C_{r\_pin} = 4 \cdot 10^{-12}$

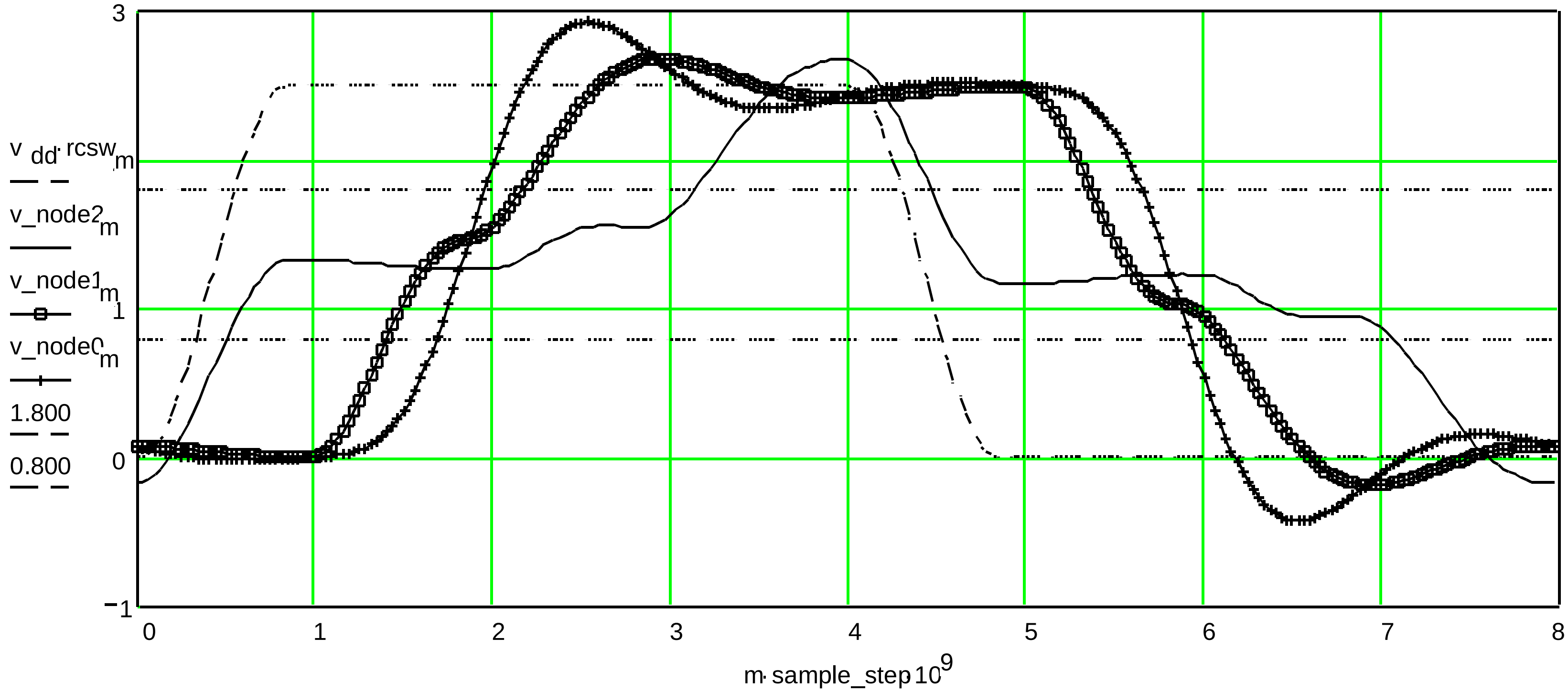
$C_{r\_pad} = 1.43 \cdot 10^{-12}$

$L_{r\_sig\_pin} = 1.72 \cdot 10^{-8}$

$L_{r\_com\_pin} = 1.61 \cdot 10^{-8}$

GMII receiver Pi network with Lucent Values

Source (Series) Termination



$v_{dd} = 2.5$

$rise\_time = 5 \cdot 10^{-10}$

$R_{d\_out} = 0$

$C_{d\_pad} = 1 \cdot 10^{-15}$

$C_{d\_pin} = 1 \cdot 10^{-15}$

$L_{d\_sig\_pin} = 1 \cdot 10^{-12}$

$L_{d\_com\_pin} = 1 \cdot 10^{-12}$

$R_{ser} = 50$

$C_{R} = 1 \cdot 10^{-15}$

$L_{R} = 1 \cdot 10^{-12}$

$Z_{o} = 50$

$line\_length\_inch = 6$

$one\_way\_delay\_ns = 1.0001$

$C_{r\_pin} = 5 \cdot 10^{-13}$

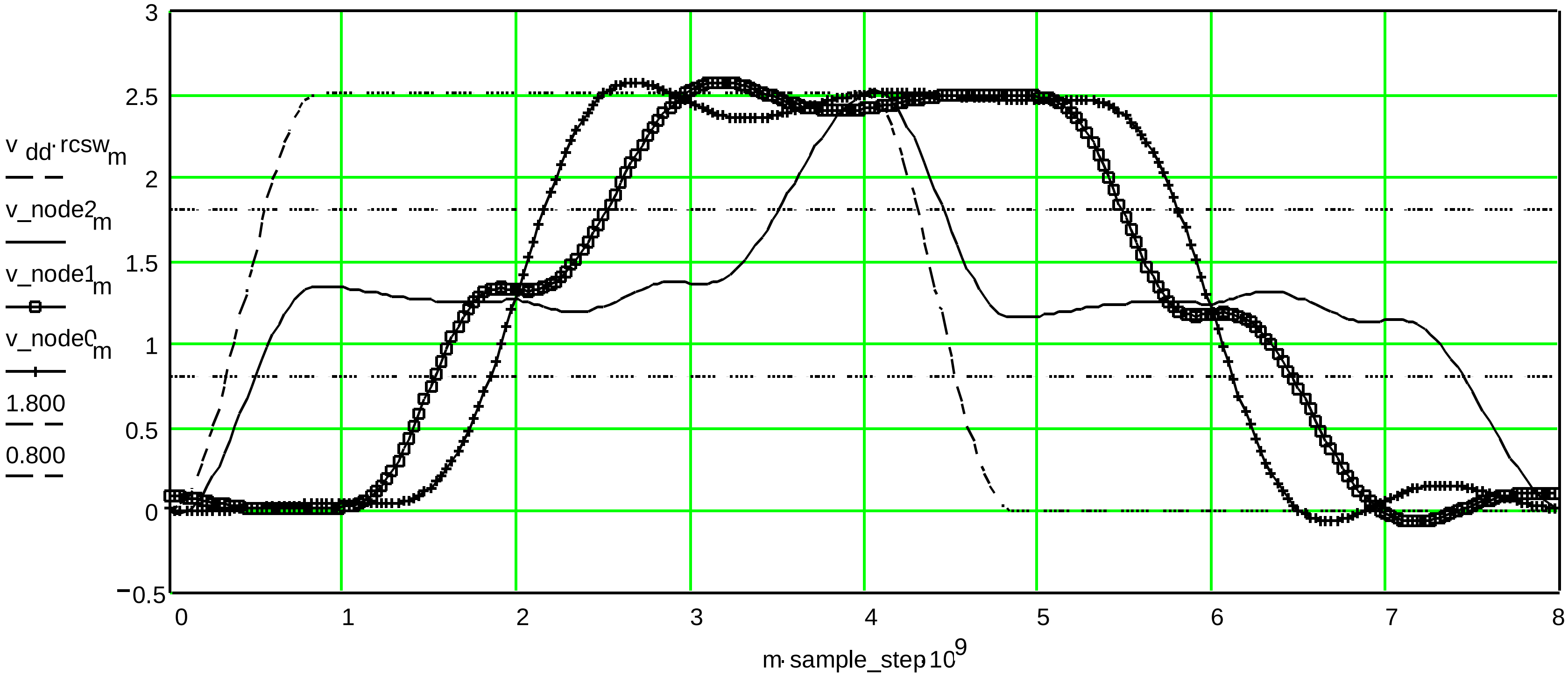
$C_{r\_pad} = 4.5 \cdot 10^{-12}$

$L_{r\_sig\_pin} = 1 \cdot 10^{-8}$

$L_{r\_com\_pin} = 1 \cdot 10^{-8}$

GMII receiver Pi network with National Values

Source (Series) Termination



$v_{dd} = 2.5$

$rise\_time = 5 \cdot 10^{-10}$

$R_{d\_out} = 0$

$C_{d\_pad} = 1 \cdot 10^{-15}$

$C_{d\_pin} = 1 \cdot 10^{-15}$

$L_{d\_sig\_pin} = 1 \cdot 10^{-12}$

$L_{d\_com\_pin} = 1 \cdot 10^{-12}$

$R_{ser} = 100$

$C_{R} = 1 \cdot 10^{-15}$

$L_{R} = 1 \cdot 10^{-12}$

$Z_{o} = 100$

$line\_length\_inch = 6$

$one\_way\_delay\_ns = 1.0002$

$C_{r\_pin} = 4 \cdot 10^{-12}$

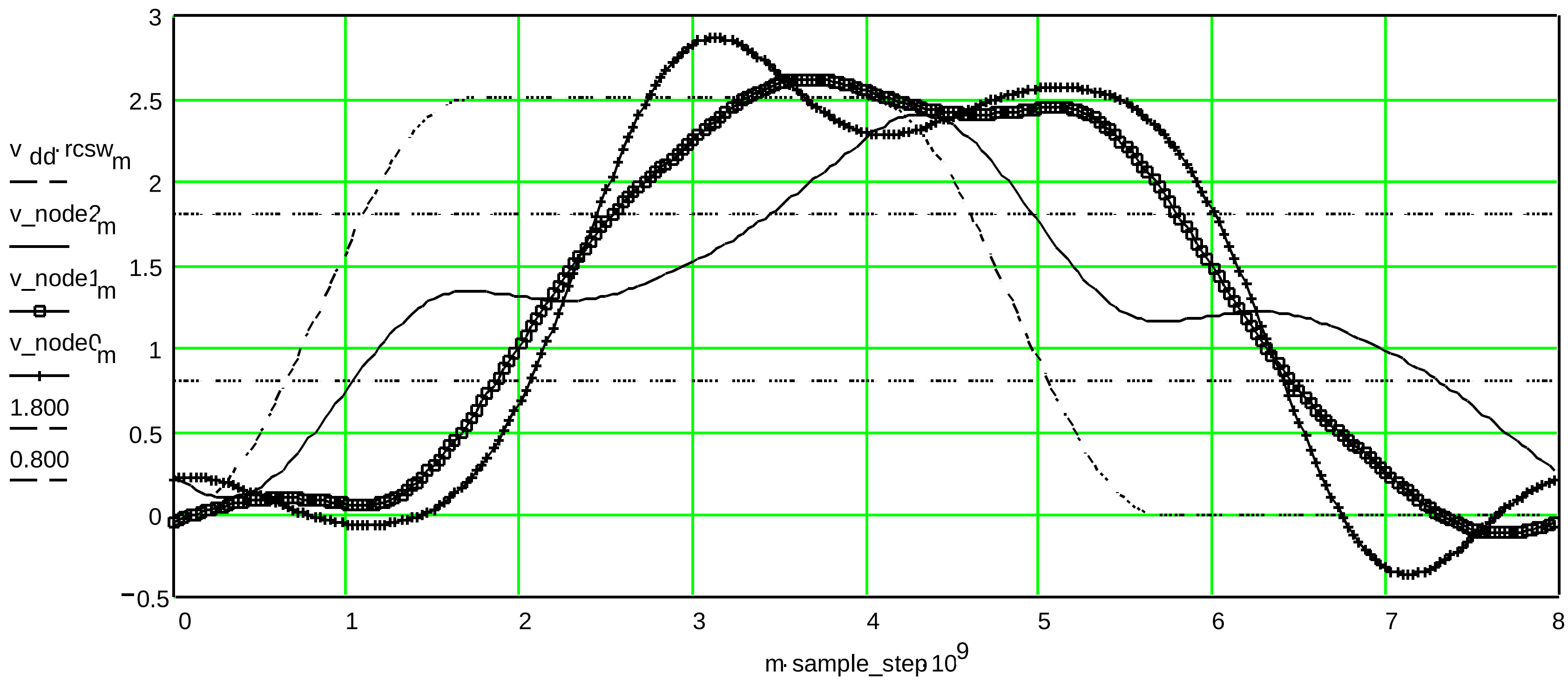
$C_{r\_pad} = 1.43 \cdot 10^{-12}$

$L_{r\_sig\_pin} = 1.72 \cdot 10^{-8}$

$L_{r\_com\_pin} = 1.61 \cdot 10^{-8}$

GMII receiver Pi network with Lucent Values and 100 Ohm line

Source (Series) Termination



$v_{dd} = 2.5$

$rise\_time = 1 \cdot 10^{-9}$

$R_{d\_out} = 0$

$C_{d\_pad} = 1 \cdot 10^{-15}$

$C_{d\_pin} = 1 \cdot 10^{-15}$

$L_{d\_sig\_pin} = 1 \cdot 10^{-12}$

$L_{d\_com\_pin} = 1 \cdot 10^{-12}$

$R_{ser} = 50$

$C_R = 1 \cdot 10^{-15}$

$L_R = 1 \cdot 10^{-12}$

$Z_o = 50$

line_length_inch = 6

one_way_delay_ns = 1.0001

$C_{r\_pin} = 4 \cdot 10^{-12}$

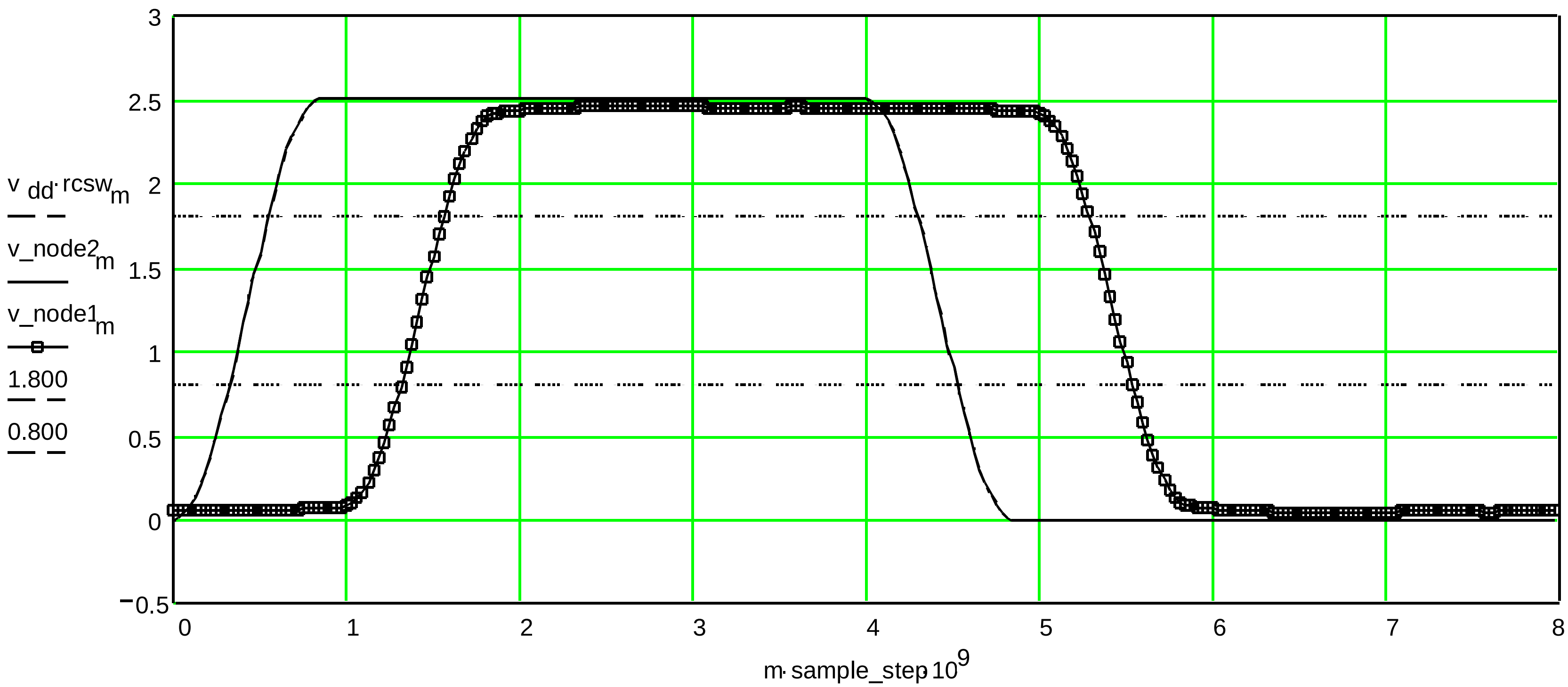
$C_{r\_pad} = 1.43 \cdot 10^{-12}$

$L_{r\_sig\_pin} = 1.72 \cdot 10^{-8}$

$L_{r\_com\_pin} = 1.61 \cdot 10^{-8}$

GMII receiver Pi network with Lucent Values and 1.0 ns risetime

End (Parallel) Termination



$v_{dd} = 2.5$

$rise\_time = 5 \cdot 10^{-10}$

$R_{d\_out} = 0$

$C_{d\_pad} = 1 \cdot 10^{-15}$

$C_{d\_pin} = 1 \cdot 10^{-15}$

$L_{d\_sig\_pin} = 1 \cdot 10^{-12}$

$L_{d\_com\_pin} = 1 \cdot 10^{-12}$

$Z_o = 50$

line_length_inch = 6

one_way_delay_ns = 1.0001

$R_t = 50$

$C_R = 1 \cdot 10^{-15}$

$L_R = 1 \cdot 10^{-12}$

$v_t = 1.25$

$C_{r\_pin} = 1 \cdot 10^{-15}$

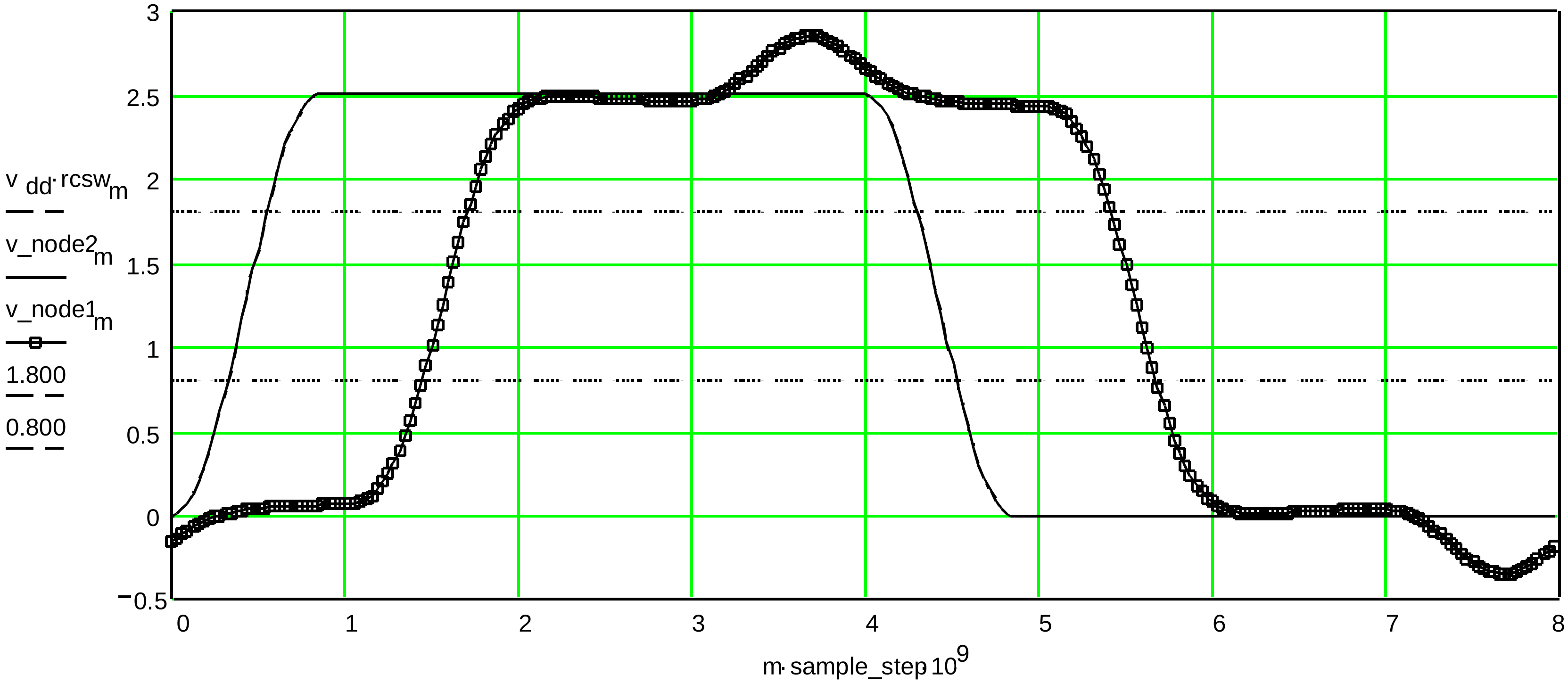
$C_{r\_pad} = 1 \cdot 10^{-15}$

$L_{r\_sig\_pin} = 1 \cdot 10^{-12}$

$L_{r\_com\_pin} = 1 \cdot 10^{-12}$

No GMII receiver loading

End (Parallel) Termination



$v_{dd} = 2.5$

$rise\_time = 5 \cdot 10^{-10}$

$R_{d\_out} = 0$

$C_{d\_pad} = 1 \cdot 10^{-15}$

$C_{d\_pin} = 1 \cdot 10^{-15}$

$L_{d\_sig\_pin} = 1 \cdot 10^{-12}$

$L_{d\_com\_pin} = 1 \cdot 10^{-12}$

$Z_o = 50$

$line\_length\_inch = 6$

$one\_way\_delay\_ns = 1.0001$

$R_t = 50$

$C_R = 1 \cdot 10^{-15}$

$L_R = 1 \cdot 10^{-12}$

$v_t = 1.25$

$C_{r\_pin} = 2 \cdot 10^{-12}$

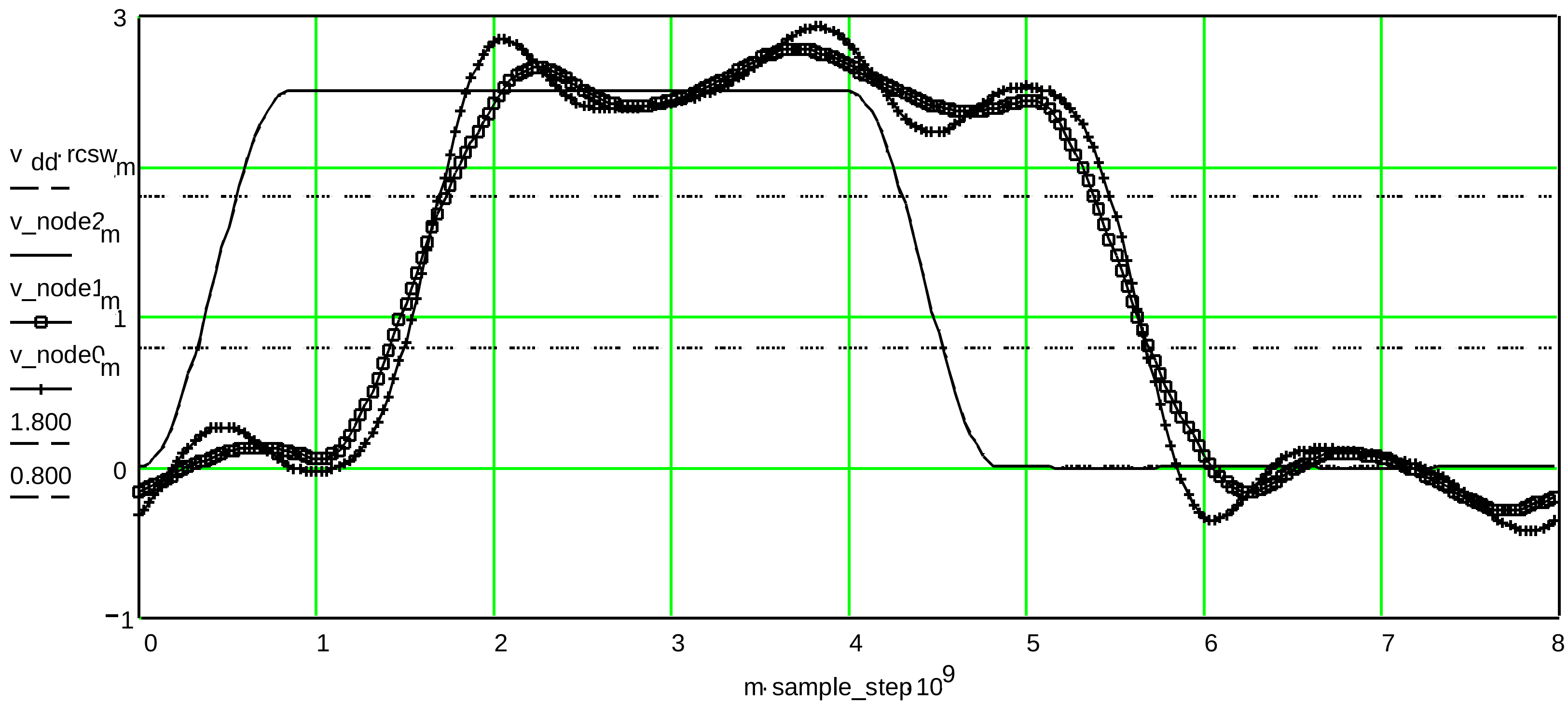
$C_{r\_pad} = 3 \cdot 10^{-12}$

$L_{r\_sig\_pin} = 1 \cdot 10^{-12}$

$L_{r\_com\_pin} = 1 \cdot 10^{-12}$

5 pF at the GMII receiver end of the line

End (Parallel) Termination



$v_{dd} = 2.5$

$rise\_time = 5 \cdot 10^{-10}$

$R_{d\_out} = 0$

$C_{d\_pad} = 1 \cdot 10^{-15}$

$C_{d\_pin} = 1 \cdot 10^{-15}$

$L_{d\_sig\_pin} = 1 \cdot 10^{-12}$

$L_{d\_com\_pin} = 1 \cdot 10^{-12}$

$Z_o = 50$

$line\_length\_inch = 6$

$one\_way\_delay\_ns = 1.0001$

$R_t = 50$

$C_R = 1 \cdot 10^{-15}$

$L_R = 1 \cdot 10^{-12}$

$v_t = 1.25$

$C_{r\_pin} = 2 \cdot 10^{-12}$

$C_{r\_pad} = 2 \cdot 10^{-12}$

$L_{r\_sig\_pin} = 6 \cdot 10^{-9}$

$L_{r\_com\_pin} = 2 \cdot 10^{-9}$

GMII receiver Pi network with BGA Values

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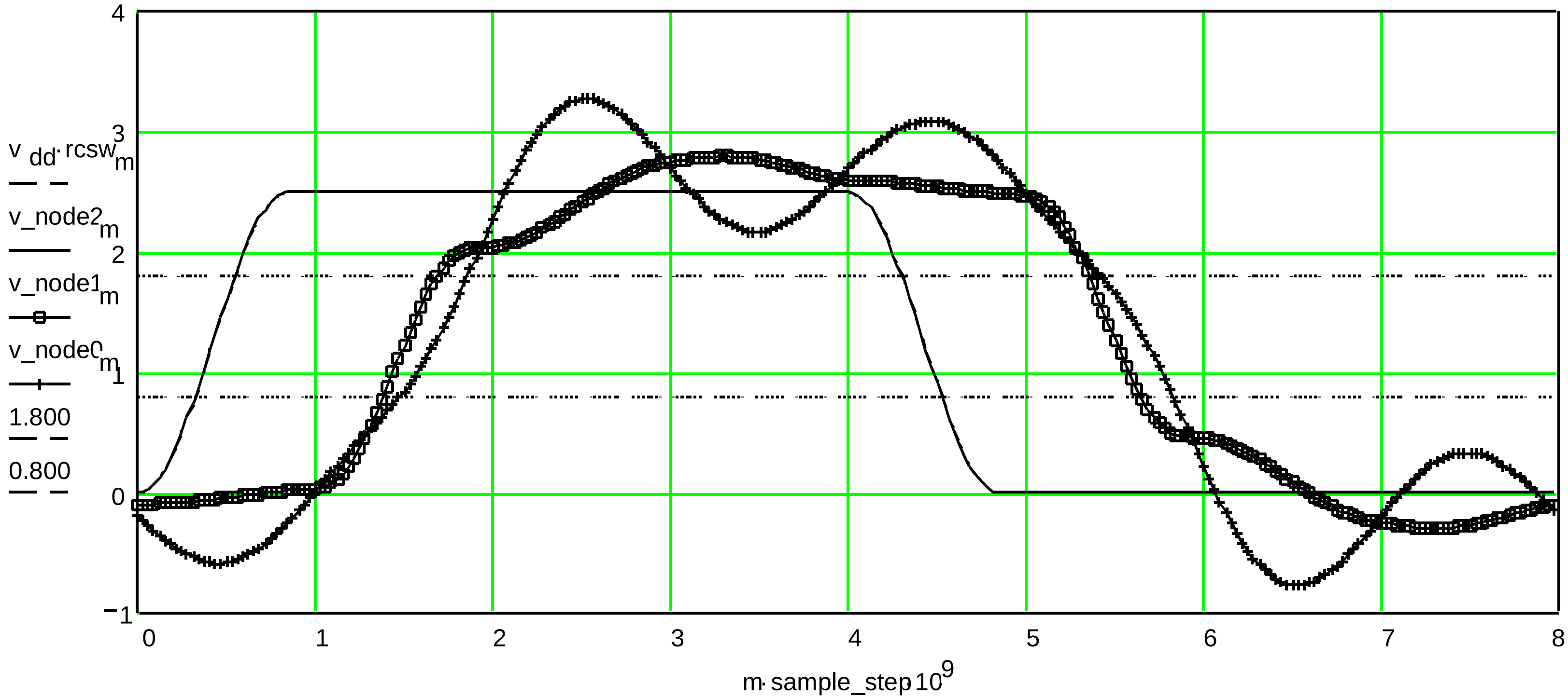
End (Parallel) Termination



$v_{dd} = 2.5$

$rise\_time = 5 \cdot 10^{-10}$

$R_{d\_out} = 0$

$C_{d\_pad} = 1 \cdot 10^{-15}$

$C_{d\_pin} = 1 \cdot 10^{-15}$

$L_{d\_sig\_pin} = 1 \cdot 10^{-12}$

$L_{d\_com\_pin} = 1 \cdot 10^{-12}$

$Z_o = 50$

$line\_length\_inch = 6$

$one\_way\_delay\_ns = 1.0001$

$R_t = 50$

$C_R = 1 \cdot 10^{-15}$

$L_R = 1 \cdot 10^{-12}$

$v_t = 1.25$

$C_{r\_pin} = 4 \cdot 10^{-12}$

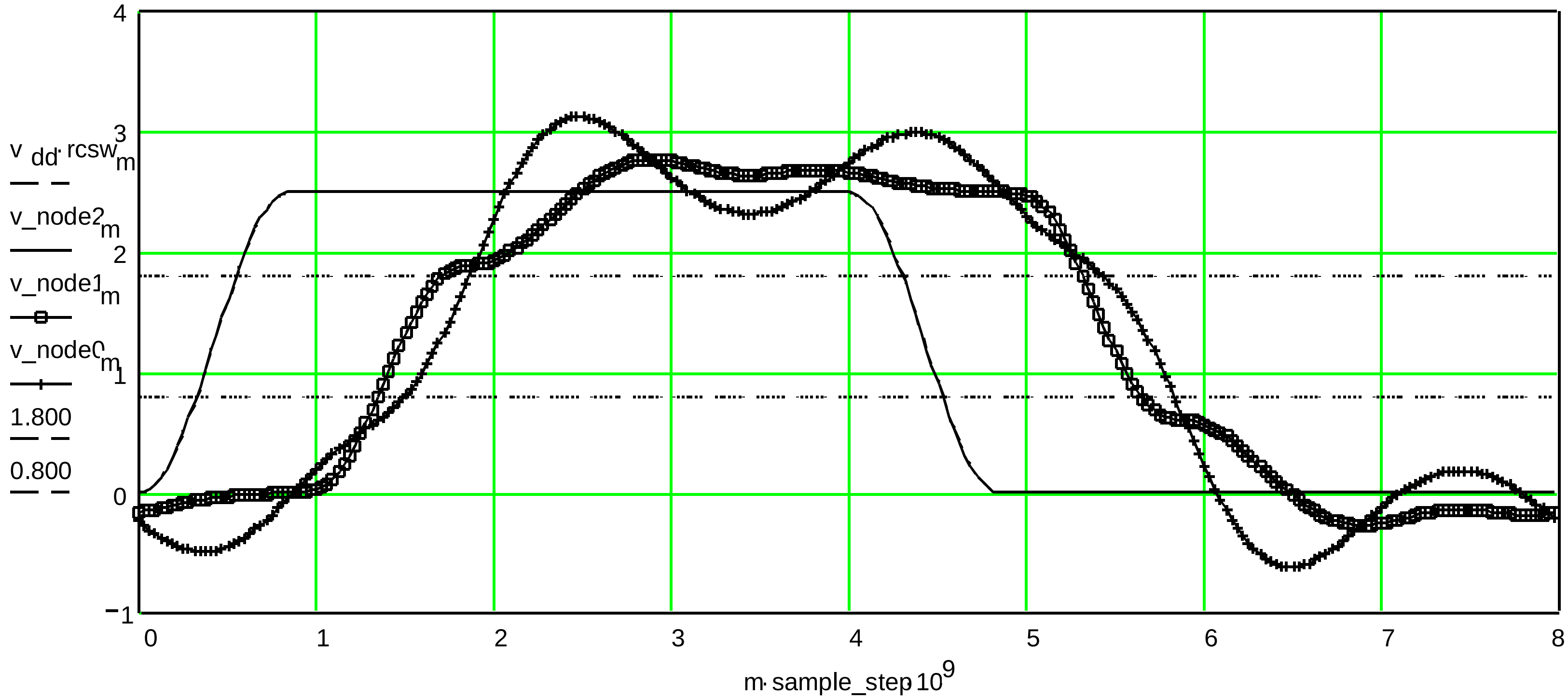
$C_{r\_pad} = 1.43 \cdot 10^{-12}$

$L_{r\_sig\_pin} = 1.72 \cdot 10^{-8}$

$L_{r\_com\_pin} = 1.61 \cdot 10^{-8}$

GMII receiver Pi network with Lucent Values

End (Parallel) Termination



$v_{dd} = 2.5$	$C_{d\_pad} = 1 \cdot 10^{-15}$	$Z_o = 50$	$R_t = 50$	$C_{r\_pin} = 5 \cdot 10^{-13}$
$rise\_time = 5 \cdot 10^{-10}$	$C_{d\_pin} = 1 \cdot 10^{-15}$	$line\_length\_inch = 6$	$C_R = 1 \cdot 10^{-15}$	$C_{r\_pad} = 4.5 \cdot 10^{-12}$
$R_{d\_out} = 0$	$L_{d\_sig\_pin} = 1 \cdot 10^{-12}$	$one\_way\_delay\_ns = 1.0001$	$L_R = 1 \cdot 10^{-12}$	$L_{r\_sig\_pin} = 1 \cdot 10^{-8}$
	$L_{d\_com\_pin} = 1 \cdot 10^{-12}$		$v_t = 1.25$	$L_{r\_com\_pin} = 1 \cdot 10^{-8}$

GMII receiver Pi network with National Values

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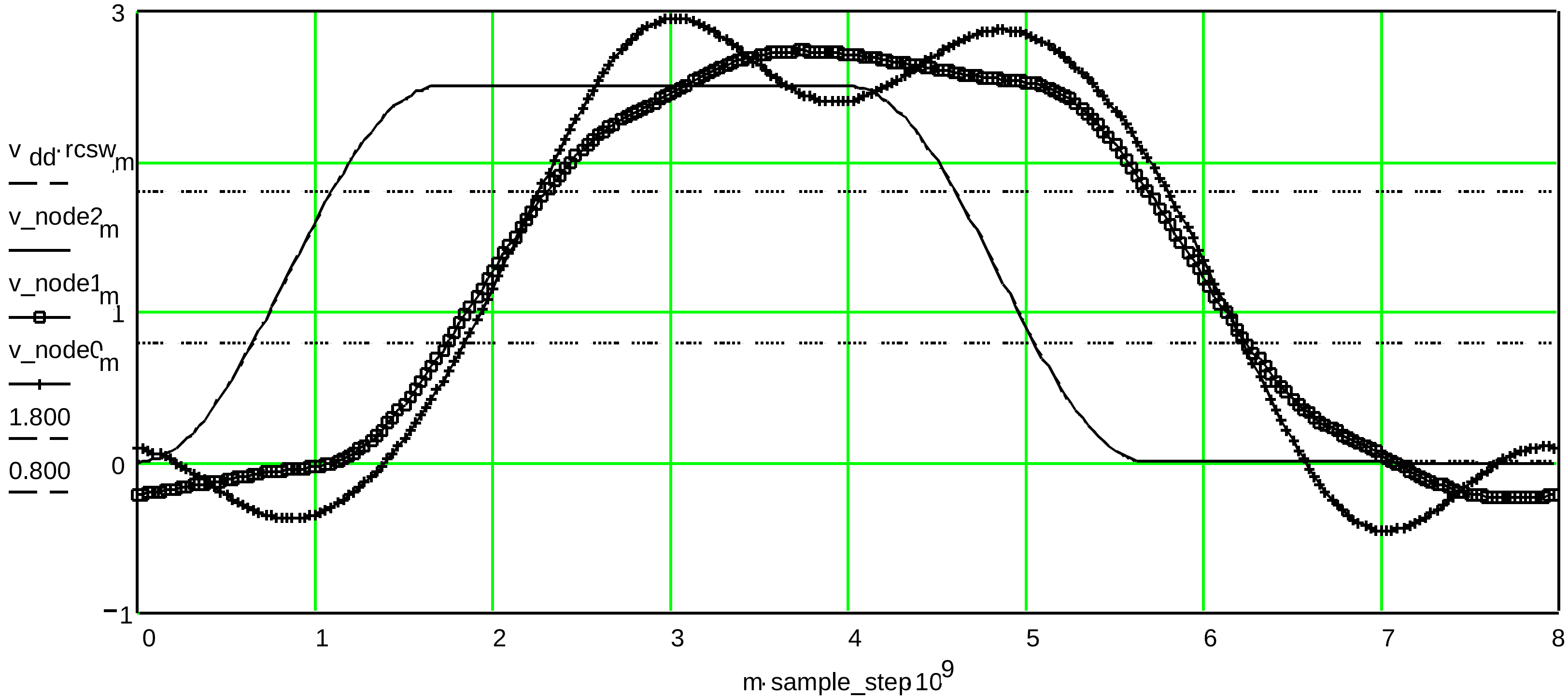
End (Parallel) Termination



$v_{dd} = 2.5$

$rise\_time = 1 \cdot 10^{-9}$

$R_{d\_out} = 0$

$C_{d\_pad} = 1 \cdot 10^{-15}$

$C_{d\_pin} = 1 \cdot 10^{-15}$

$L_{d\_sig\_pin} = 1 \cdot 10^{-12}$

$L_{d\_com\_pin} = 1 \cdot 10^{-12}$

$Z_o = 50$

line_length_inch = 6

one_way_delay_ns = 1.0001

$R_t = 50$

$C_R = 1 \cdot 10^{-15}$

$L_R = 1 \cdot 10^{-12}$

$v_t = 1.25$

$C_{r\_pin} = 4 \cdot 10^{-12}$

$C_{r\_pad} = 1.43 \cdot 10^{-12}$

$L_{r\_sig\_pin} = 1.72 \cdot 10^{-8}$

$L_{r\_com\_pin} = 1.61 \cdot 10^{-8}$

GMII receiver Pi network with Lucent Values and 1.0 ns risetime

Proposed GMII Electrical Specifications

DC Specifications

The DC characteristics of GMII drivers and receivers shall comply with the values given in the following table.

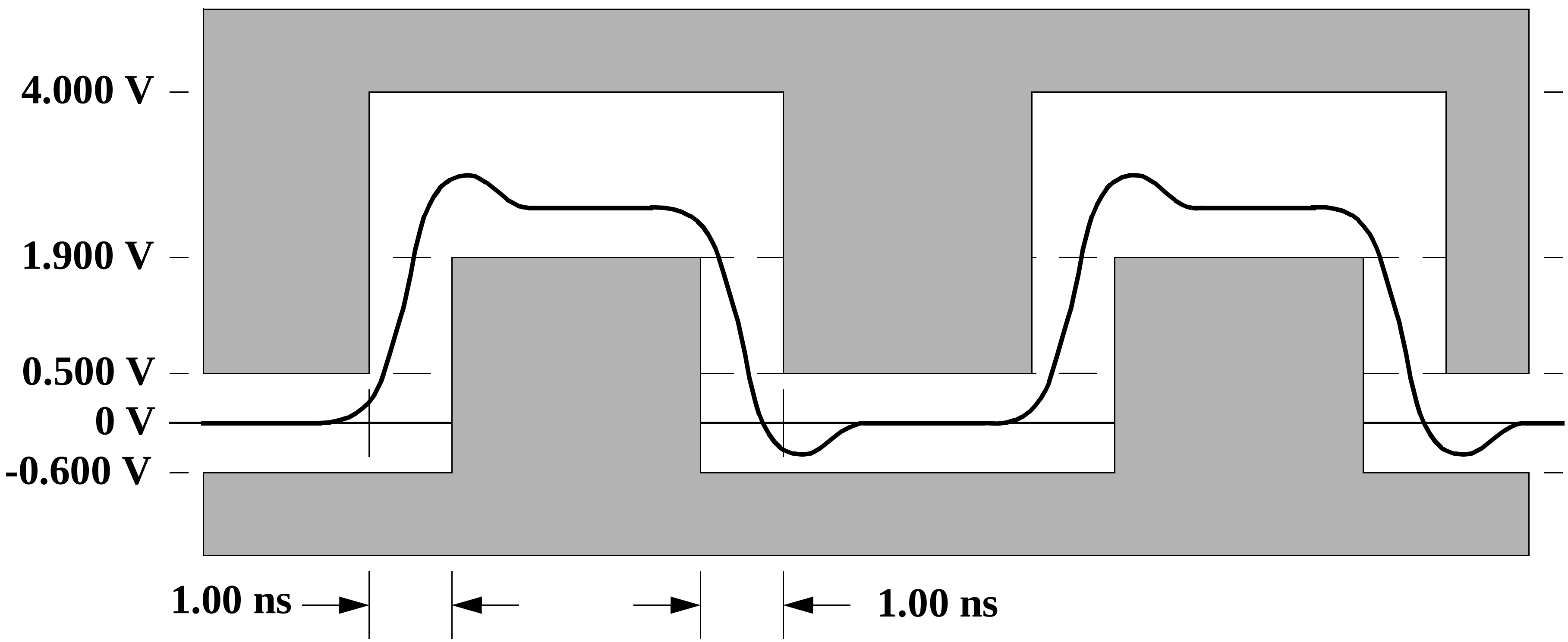
Symbol	Parameter	Conditions		Min	Max	Units
V_{OH}	Output High Voltage	I_{OH} = -1.0mA	V_{CC} = Min	2.00	V_{CC}	V
V_{OL}	Output Low Voltage	I_{OL} = 1.0mA	V_{CC} = Min	GND	0.40	V
V_{IH}	Input High Voltage			1,60	-	V
V_{IL}	Input Low Voltage			-	0,80	V
I_{IH}	Input High Current	V_{CC} = Max	V_{IN} = 2.0V	-	40	µA
I_{IL}	Input Low Current	V_{CC} = Max	V_{IN} = 0.4V	-600	-	µA
[1] Vcc equal to 3.6V max.						

AC Specifications

The minimum setup time and hold time of a GMII receiver shall be 2.0 ns and 1.0 ns respectively.

The input signal at the pins of a GMII receiver shall comply with the "GMII Receiver Input Potential Template" shown in the following figure.

GMII Receiver Input Potential Template



The signal at the receiver end of the 1.00 ns delay, 50 Ohm +/- 15% transmission line shown in the following figure shall comply with the "GMII Receiver Input Potential Template" when the transmission line is driven by a GMII driver and terminated with the termination network specified the vendor of the driver for this application.