



# EMD Differential Transmission Line Model Rev 1.0

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# Subckt Elements

- R Resistor
- L Inductor
- C Capacitor
- G Conductance
- K Element
- T Tline
- W Line
  - RLGC
  - Table Driven
- S parameter element
- Controlled Sources
- V DC Voltage
- X Subckt
- Other possible elements
  - Impulse Response
  - Poles and Zeros
- Miscellaneous
  - .include
  - .parameter
- Corner
  - Slow/Typ/Fast
  - Min/Max Noise
  - Min/Max CrossTalk

# Assumption

**Reference Nodes is perfect Ground at both ends of Differential Transmission Line**

**Length is 1”**

**Nodes are D.H, D.L, P.H, P.L**

- D Die side**
- P Package Side**
- H Active High**
- L Active Low**

# Physical Description

**Stripline**

**Length**

**Er**

**Conductivity**

**Loss tangent**

**Surface roughness**

**Dielectric Thickness**

**Trace height above plane**

**Trace widths**

**Trace thickness**

**Trapezoidal shape**

**Trace separation**

# Physical/Electrical Description

**Length**

**Zodd**

**Zeven**

**Er**

**Conductivity**

**Loss tangent**

**Surface roughness**

**Trace widths**

**Trace thickness**

# Lumped Model

C_D.H	D.H	0	C=<capacitance>
R_H	D.H	H	R=<resistance>
L_H	P.H	H	L=<inductance>
C_P.H	P.H	0	C=<capacitance>
C_D.L	D.L	0	C=<capacitance>
R_L	D.L	L	R=<resistance>
L_L	P.L	L	L=<inductance>
C_P.L	P.L	0	C=<capacitance>

# Coupled Lumped Model

```
C_D.H D.H 0 C=<capacitance>
R_H D.H H R=<resistance>
L_H P.H H L=<inductance>
C_P.H P.H 0 C=<capacitance>
C_D.L D.L 0 C=<capacitance>
R_L D.L L R=<resistance>
L_L P.L L L=<inductance>
C_P.L P.L 0 C=<capacitance>
KL L_H L_L K=<coupling>
C_D D.H D.L C=<capacitance>
C_P P.H P.L C=<capacitance>
```

# Lossless Uncoupled Tlines

```
TH D.H P.H Td=<delay> Zo=<impedance>  
TL D.L P.L Td=<delay> Zo=<impedance>
```



# Other Model Formats

```
Other D.H D.L P.H P.L L=.0254 RLGCmodel=<RLGCmodel>
Other D.H D.L P.H P.L L=.0254 TABLEmodel=<TABLEmodel>
Other D.H D.L P.H P.L TouchstoneFile=<file>.s4p
Other D.H D.L P.H P.L ImpulseFile=<file>.i4p
Other D.H D.L P.H P.L PoleZeroModel=<PoleZeroModel>
Other D.H D.L P.H P.L LadderModel=<LadderModel>
Other D.H D.L P.H P.L ?=<?>
```

# RLGC Models

## RLGCmodel

Lo Co Ro Go Rs Gd

Proprietary?

Accurate and concise representation of frequency dependence

## TABLEmodel

RLMODEL

CMODEL

LMODEL

GMODEL

ICM is same as TABLEmodel except supports lumped and sparse

Resistance

Capacitance

Inductance

Conductance

# Touchstone File

**Touchstone 1.0 is all that is required**

**The person creating the EMD model “knows” how the s4p was generated, and therefore knows how to associate the nodes of the differential pair with the ports of the s4p data**

**If model was NNFF then**

**Other D.H D.L P.H P.L TouchstoneFile=<file>.s4p**

**If model was NFNF then**

**Other D.H P.H D.L P.L TouchstoneFile=<file>.s4p**

**Touchstone 2.0 can save 2x disc space for sNp where N >4**

**Sparse Touchstone representation will be required for large coupled systems**