How to write BIRD 158 models with “official” IBIS syntax

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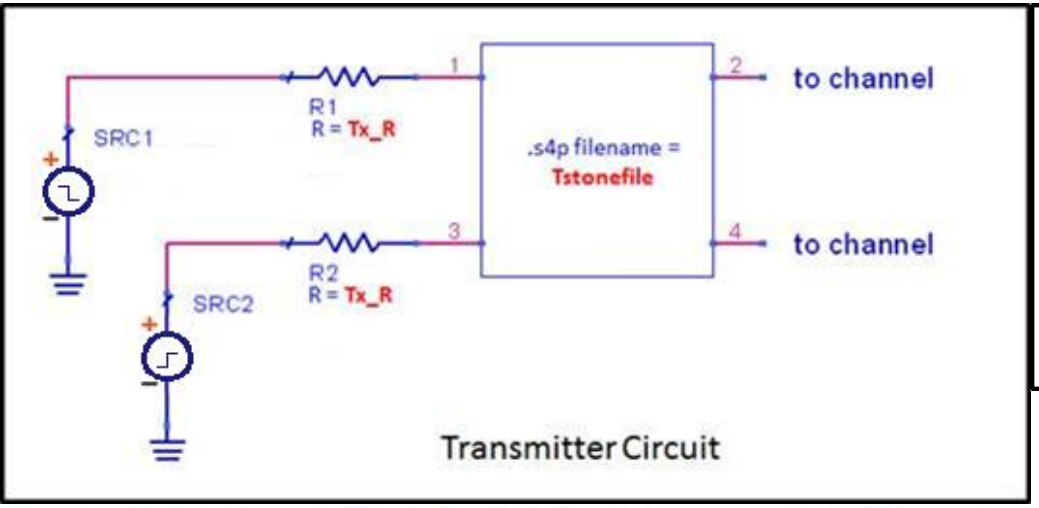
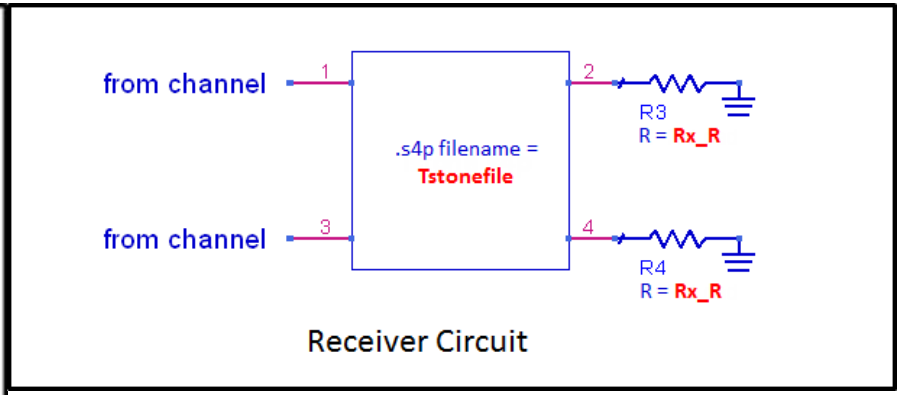
What is a BIRD 158 model?

- **BIRD 158 proposes to use Touchstone (S-parameter) files to model the analog portions of IBIS-AMI models (replacing the I-V / V-t curve and C_comp based legacy analog models)**
  - This idea dates back to SiSoft's Opal initiative, except that BIRD 158 only talks about Touchstone files (and no RC subcircuits)
  - BIRD 158 has not been approved by the IBIS Open Forum yet, consequently it is not in the IBIS specification
  - However, some EDA vendors have implemented support for BIRD 158 models in their tools and models are actively being created with this syntax





What is BIRD 160?

- **As soon as the IBIS-ISS specification became official, BIRD 160 was submitted to add IBIS-ISS as an official language for the [External Circuit] and [External Model] keywords**
  - IBIS-ISS is a subset of HSPICE with support for all passive components, such as R, L, C, W, S-elements and the linear versions of the controlled sources (E, F, G, H-elements)
  - The use of IBIS-ISS with the [External ***] keywords gave IBIS the ability to support S-parameter (Touchstone) files for buffer and/or on-die interconnect modeling
  - Stretching some of the IBIS rules, this also allows S-parameter package modeling with [External Circuit]
  - BIRD 160 also addresses parameter passing for the [External ***] keywords which was absent from the IBIS specification before

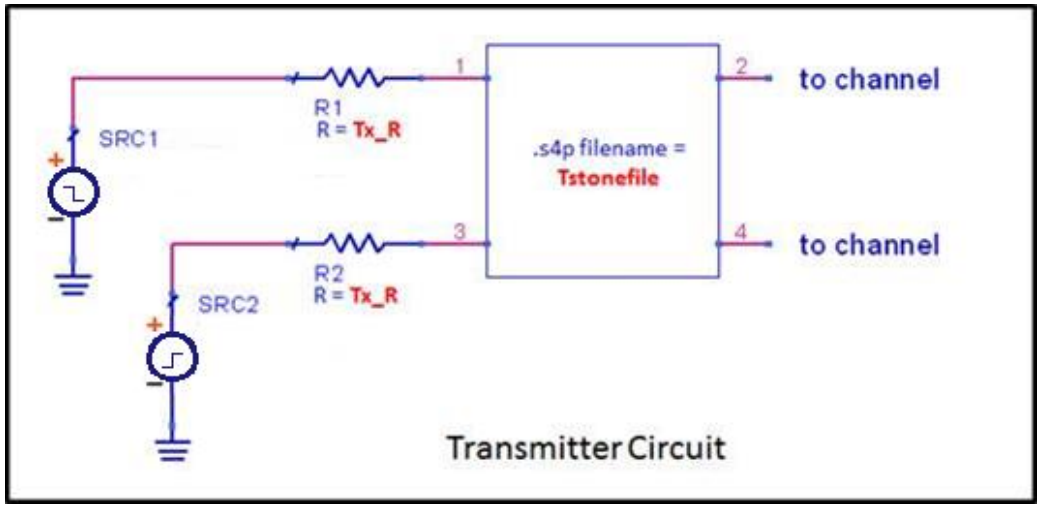
- **BIRD 160 was approved by the IBIS Open Forum in May 2013 and is part of the IBIS specification since v6.0 (September 2013)**

Comparing BIRD 158 and 160

- **Both BIRDs support S-parameter models for analog buffer modeling**
  - BIRD 158 places the Touchstone file pointer into the .ami file, making this approach available ***only for AMI simulations***
  - This allows the AMI engine to process the S-parameter model directly (in the frequency domain) and eliminates the need for time domain channel characterization simulations, ***but only if Tx and Rx <u>both</u> use this syntax***
  - This may result in ***some performance and numerical accuracy advantages***
  - BIRD 160 uses the subcircuit referenced by the [External Model] as the pointer to the Touchstone file, making it ***generally available for any IBIS simulation***
  - These models would normally be executed in the time domain to perform the channel characterization or any other simulations
  - This is ***somewhat slower*** and may suffer ***some numerical accuracy issues***
  - The BIRD 160 syntax ***does not require*** that both Tx and Rx should use S-parameters as the analog buffer models (mixed models will still work)
  - However, EDA tools could detect whether the subcircuits under the Tx and Rx [External Model]s contain one and only one .s4p file reference, and if so, they may choose to employ a "BIRD158" simulation flow (in the frequency domain) if so desired

A BIRD 158 Tx .ami file excerpt

```
 (Model_Specific
    (Tx_V (Usage Info) (Type Float) (Value 1.0)
        (Description "Open circuit voltage swing")
    )
    (Tx_R (Usage Info) (Type Float) (Corner 50 51 49)
        (Description "Tx termination")
    )
    (Tstonefile (Usage Info) (Type String) (Corner "Tx_typ.s4p" "Tx_min.s4p" "Tx_max.s4p")
        (Description "S-parameter analog buffer model")
    )
...
...
```



The same Tx model with BIRD 160 syntax

```
[Model]  Tx158using160syntax
Model_type  Output_diff                | This is a "True differential" model

[Temperature Range] 27 100 0
[Voltage Range]  1  1  1

[Algorithmic Model]
Executable  Windows_VisualStudio_64  AMImodelTx.dll  AMImodelTx.ami
[End Algorithmic Model]

[Ramp]
dV/dt_r  0.27/10p  0.26/9p  0.28/11p
dV/dt_f  0.27/10p  0.26/9p  0.28/11p

[External Model]
Language IBIS-ISS

Corner   Typ   ISS_wrapper.inc   TxSubcircuitTyp
Corner   Min   ISS_wrapper.inc   TxSubcircuitMin
Corner   Max   ISS_wrapper.inc   TxSubcircuitMax

Ports   StimP  A_signal_pos  StimN  A_signal_neg  SPref

|D_to_A  d_port   port1  port2   vlow  vhigh  trise     tfall     corner_name  polarity
D_to_A   D_drive  StimP  SPref   0.0   1.0    16.67p    16.67p    Typ          Non-Inverting
D_to_A   D_drive  StimP  SPref   0.0   1.0    15.00p    15.00p    Min          Non-Inverting
D_to_A   D_drive  StimP  SPref   0.0   1.0    18.33p    18.33p    Max          Non-Inverting

D_to_A   D_drive  StimN  SPref   0.0   1.0    16.67p    16.67p    Typ          Inverting
D_to_A   D_drive  StimN  SPref   0.0   1.0    15.00p    15.00p    Min          Inverting
D_to_A   D_drive  StimN  SPref   0.0   1.0    18.33p    18.33p    Max          Inverting

[End External Model]
```

These two sets of numbers are equivalent!

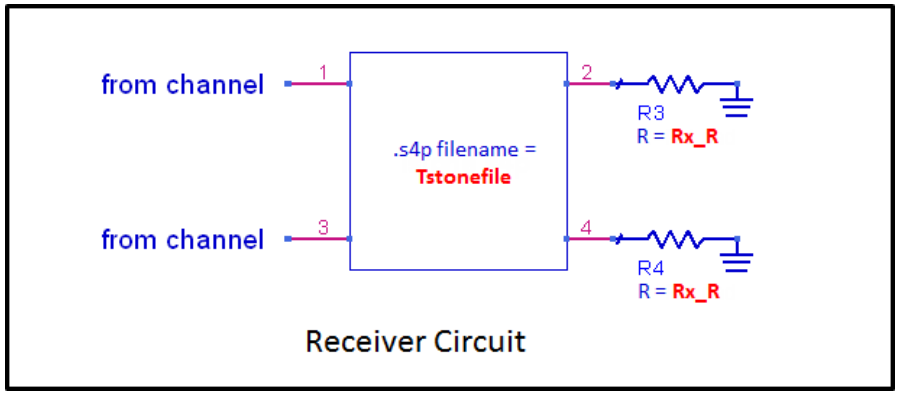
[Ramp] uses 20-80% values
trise/tfall use 0-100% values

The IBIS-ISS wrapper file for Tx

```
************************************************************
.subckt  TxSubcircuitTyp  P1R  P2  P3R  P4  RefNode
R0  RefNode  0  R=0.0001
Rp1  P1  P1R  R=50
Rp3  P3  P3R  R=50

S1  P1  P2  P3  P4  0  mname=SmodelNameTyp
.MODEL  SmodelNameTyp  S  N=4  TSTONEFILE=Tx_typ.s4p
.ends
************************************************************
.subckt  TxSubcircuitMin  P1R  P2  P3R  P4  RefNode
R0  RefNode  0  R=0.0001
Rp1  P1  P1R  R=51
Rp3  P3  P3R  R=51

S1  P1  P2  P3  P4  0  mname=SmodelNameMin
.MODEL  SmodelNameMin  S  N=4  TSTONEFILE=Tx_min.s4p
.ends
************************************************************
.subckt  TxSubcircuitMax  P1R  P2  P3R  P4  RefNode
R0  RefNode  0  R=0.0001
Rp1  P1  P1R  R=49
Rp3  P3  P3R  R=49

S1  P1  P2  P3  P4  0  mname=SmodelNameMax
.MODEL  SmodelNameMax  S  N=4  TSTONEFILE=Tx_max.s4p
.ends
************************************************************
```

A BIRD 158 Rx .ami file excerpt

```
(Model_Specific
   (Rx_R (Usage Info) (Type Float) (Corner 50 51 49)
       (Description "Rx termination")
   )
   (Tstonefile (Usage Info) (Type String) (Corner "Rx_typ.s4p" "Rx_min.s4p" "Rx_max.s4p")
       (Description "S-parameter analog buffer model")
   )
...
...
```



The same Rx model with BIRD 160 syntax

```
[Model]  Rx158using160syntax
Model_type  Input_diff              | This is a "True differential" model

[Temperature Range] 27 100 0
[Voltage Range]  1  1  1

[Algorithmic Model]
Executable  Windows_VisualStudio_64  AMImodelRx.dll  AMImodelRx.ami
[End Algorithmic Model]

[External Model]
Language IBIS-ISS

Corner   Typ   ISS_wrapper.inc   RxSubcircuitTyp
Corner   Min   ISS_wrapper.inc   RxSubcircuitMin
Corner   Max   ISS_wrapper.inc   RxSubcircuitMax

Ports   A_signal_pos  A_RxOut_pos  A_signal_neg  A_RxOut_neg

| A_to_D  d_port     port1         port2          vlow   vhigh    corner_name
A_to_D    D_receive  A_RxOut_pos   A_RxOut_neg    -0.1   0.1      Typ

[End External Model]
```

The IBIS-ISS wrapper file for Rx

```
************************************************************
.subckt  RxSubcircuitTyp  P1  P2  P3  P4

Rp2  P2  0  R=50
Rp4  P4  0  R=50

S1  P1  P2  P3  P4  0  mname=SmodelNameTyp
.MODEL  SmodelNameTyp  S  N=4  TSTONEFILE=Rx_typ.s4p

.ends
************************************************************
.subckt  RxSubcircuitMin  P1  P2  P3  P4

Rp2  P2  0  R=51
Rp4  P4  0  R=51

S1  P1  P2  P3  P4  0  mname=SmodelNameMin
.MODEL  SmodelNameMin  S  N=4  TSTONEFILE=Rx_min.s4p

.ends
************************************************************
.subckt  RxSubcircuitMax  P1  P2  P3  P4

Rp2  P2  0  R=49
Rp4  P4  0  R=49

S1  P1  P2  P3  P4  0  mname=SmodelNameMax
.MODEL  SmodelNameMax  S  N=4  TSTONEFILE=Rx_max.s4p

.ends
************************************************************
```

Conclusion

- **A BIRD 158 model using S-parameter analog buffer models can be easily written using the BIRD 160 syntax**
- **EDA vendors can apply their favorite simulation algorithms or flows, regardless of what syntax is used to write the IBIS files**
- **Etc…**