IBIS-AMI Terminology Proposal

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Background

- We use terminology from LTI system theory to describe IBIS-AMI simulation results, for example:
  - Waveform @ RX sampler
    $= p(t) \otimes b(t) \otimes h_{TE}(t) \otimes h_{CR}(t) \otimes h_{RE}(t)$

- AMI models can provide equalization from either (or both) AMI_Init and AMI_Getwave calls, and those equalization behaviors can be different:
  - TX equalization separated into $h_{TEI}(t)$ and $h_{TEG}(t)$
  - RX equalization separated into $h_{REI}(t)$ and $h_{REG}(t)$

The Issue

- Referring to TX and RX Getwave equalization as $h_{TEG}(t)$ and $h_{REG}(t)$ implies the result can be derived through convolution, which isn't true
- $h_{TEG}(t)$ and $h_{REG}(t)$ can be nonlinear and/or time-varying, which is inconsistent with LTI terminology
- Consider a waveform from a TX model with AMI_Init and an RX DFE model with AMI_Getwave:

  $p(t) \otimes b(t) \otimes h_{TEI}(t) \otimes h_{CR}(t) \otimes h_{REG}(t)$

  – Since RX GetWave behavior is non-linear, the convolution operator doesn't apply and the current terminology is imprecise

The Issue (cont'd)

- Current terminology also implies the order of operations doesn't matter, for instance

  $p(t) \otimes b(t) \otimes h_{TEI}(t) \otimes h_{CR}(t) \otimes h_{REG}(t)$

  versus

  $h_{REG}(t) \otimes p(t) \otimes b(t) \otimes h_{TEI}(t) \otimes h_{CR}(t)$

- This is incorrect when GetWave is nonlinear and/or time-varying (which it usually is!)

Proposed Solution

- Use terminology for GetWave that does not imply LTI behavior
- $G_{XEG\,(\,)}$ refers to a function that takes a time-domain waveform and produces a time-domain waveform:
  - AMI_Init remains $h_{TEI}(t)$ and $h_{REI}(t)$
  - AMI_GetWave becomes $G_{TEG}(\,)$ and $G_{REG}(\,)$
- The TX_Init / RX_Getwave case becomes
  - $G_{REG}(\, p(t) \otimes b(t) \otimes h_{TEI}(t) \otimes h_{CR}(t)\,)$
    - The order in which convolution is applied does not matter
    - G_{REG} is applied to the output of the final convolution

Practical Considerations

- Terminology must be suitable for plain-text communication without special fonts
  - "⊗" becomes "*" as before
  - G_{TEG}( ) and G_{REG}( ) become G_teg( ) and G_reg ( )
- There should be a benefit; new terminology should allow us to describe things more precisely and have clear discussions that weren't possible before
  - We maintain this terminology makes discussions of the "reference flow" and consequences of "Use_Init_Output" much easier

Use_Init_Output

- Use_Init_Output is independent for TX and RX models
- There are 4 possible cases to consider:

Case	TX Use_Init_Output	RX Use_Init_Output
1	False	False
2	False	True
3	True	False
4 (Default)	True	True

- The following slides consider cases where TX and RX models implement both AMI_Init and AMI_Getwave – other cases are simpler

Case 1: TX = False, RX = False

- Impulse response input to TX AMI_Init
  - $h_{CR}(t)$
- Impulse response input to RX AMI_Init
  - $h_{TEI}(t) \otimes h_{CR}(t)$
- Impulse response output from RX AMI_Init
  - $h_{TEI}(t) \otimes h_{CR}(t) \otimes h_{REI}(t)$
- Waveform input to TX AMI_Getwave
  - $p(t) \otimes b(t) \otimes h_{CR}(t)$
- Waveform input to RX AMI_Getwave
  - $G_{TEG}(p(t) \otimes b(t) \otimes h_{CR}(t))$
- Waveform output from RX AMI_Getwave
  - $G_{REG}(G_{TEG}(p(t) \otimes b(t) \otimes h_{CR}(t)))$

Case 2: TX = False, RX = True

- Impulse response input to TX AMI_Init
  - $h_{CR}(t)$
- Impulse response input to RX AMI_Init
  - $h_{TEI}(t) \otimes h_{CR}(t)$
- Impulse response output from RX AMI_Init
  - $h_{TEI}(t) \otimes h_{CR}(t) \otimes h_{REI}(t)$
- Waveform input to TX AMI_Getwave
  - $p(t) \otimes b(t) \otimes h_{CR}(t) \otimes h_{REI}(t)$
- Waveform input to RX AMI_Getwave
  - $G_{TEG}(p(t) \otimes b(t) \otimes h_{CR}(t) \otimes h_{REI}(t))$
- Waveform output from RX AMI_Getwave
  - $G_{REG}(G_{TEG}(p(t) \otimes b(t) \otimes h_{CR}(t) \otimes h_{REI}(t)))$

Case 3: TX = True, RX = False

- Impulse response input to TX AMI_Init
  - $h_{CR}(t)$
- Impulse response input to RX AMI_Init
  - $h_{TEI}(t) \otimes h_{CR}(t)$
- Impulse response output from RX AMI_Init
  - $h_{TEI}(t) \otimes h_{CR}(t) \otimes h_{REI}(t)$
- Waveform input to TX AMI_Getwave
  - $p(t) \otimes b(t) \otimes h_{CR}(t) \otimes h_{TEI}(t)$
- Waveform input to RX AMI_Getwave
  - $G_{TEG}(p(t) \otimes b(t) \otimes h_{CR}(t) \otimes h_{TEI}(t))$
- Waveform output from RX AMI_Getwave
  - $G_{REG}(G_{TEG}(p(t) \otimes b(t) \otimes h_{CR}(t) \otimes h_{TEI}(t)))$

Case 4: TX = True, RX = True

- Impulse response input to TX AMI_Init
  - $h_{CR}(t)$
- Impulse response input to RX AMI_Init
  - $h_{TEI}(t) \otimes h_{CR}(t)$
- Impulse response output from RX AMI_Init
  - $h_{TEI}(t) \otimes h_{CR}(t) \otimes h_{REI}(t)$
- Waveform input to TX AMI_Getwave
  - $p(t) \otimes b(t) \otimes h_{CR}(t) \otimes h_{TEI}(t) \otimes h_{REI}(t)$
- Waveform input to RX AMI_Getwave
  - $G_{TEG}(p(t) \otimes b(t) \otimes h_{CR}(t) \otimes h_{TEI}(t) \otimes h_{REI}(t))$
- Waveform output from RX AMI_Getwave
  - $G_{REG}(G_{TEG}(p(t) \otimes b(t) \otimes h_{CR}(t) \otimes h_{TEI}(t) \otimes h_{REI}(t)))$

Observations

- In all cases, the best-case (least distorted) input to TX AMI_GetWave is $p(t) \otimes b(t) \otimes h_{CR}(t)$
  - Input bit stream may not be readily recoverable, which has implications for the model code
- In case 3, the input to TX AMI_GetWave includes the TX_AMI equalization $h_{TEI}(t)$
  - TX AMI_GetWave call must be written accordingly. Not a big problem since $h_{TEI}(t)$ is contained in the same model
- In cases 2 and 4, the input to TX AMI_GetWave includes the RX AMI_Init equalization $h_{REI}(t)$
  - Potentially an issue, since the writer of TX AMI_GetWave has no control over $h_{REI}(t)$

Summary

- New terminology for AMI_GetWave math is more precise; supports clearer discussions
- Reference flows outlined with new terminology for different values of Use_Init_Output
- Potential modeling issues identified for subsequent discussion