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Study of Solving IBIS Single VT

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SYNOPSYS
Asian IBIS Summit Meeting
Shanghai, China
November 11, 2008

Outline

- Introduce of VT Solving
- Try Two Methods to Solve Single VT
  - Method 1: Experiential Way
  - Method 2: Impose Constraint
  - Comparison of Two Methods
- Conclusions

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Introduce VT Solving

- VT waveforms occur firstly in IBIS2.0

- VT waveforms describe transient characteristic of buffer, and be used to solving PU,PD scaling coefficients in pre-simulation computing.

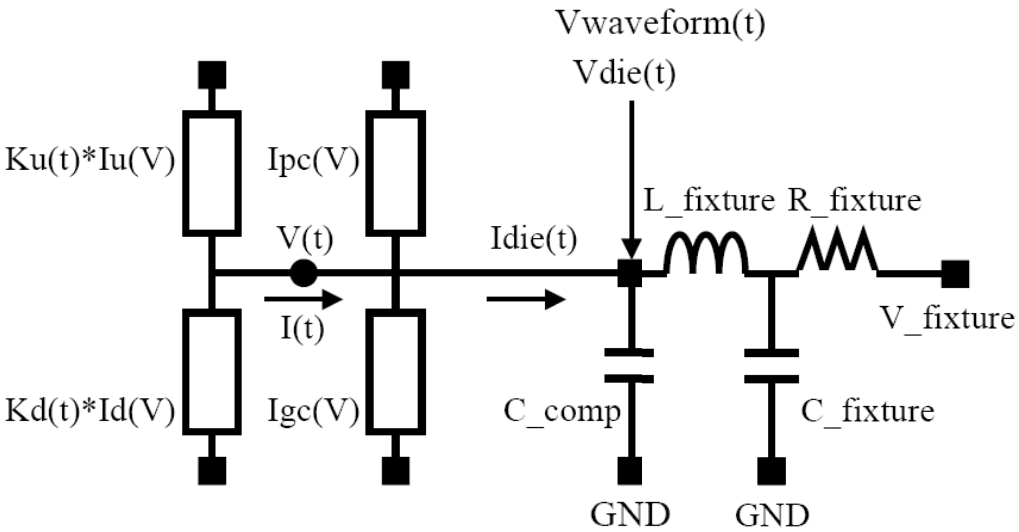
- The well known 2EQ/2UK algorithm is for two VT waveforms – one waveform for one linear equation.

  Arpad Muranyi: http://www.vhdl.org/pub/ibis/summits/mar06/muranyi1.pdf
  Bob Ross: http://www.vhdl.org/pub/ibis/summits/jun03a/ross.pdf

- Theoretically, there is no solution for single VT – one linear equation, but two unknowns.

Introduce of VT Solving

- Recall 2EQ/2UK algorithm



$$0 = Ku(t) * Iu(V_{wfm1}(t)) + Ipc(V_{wfm1}(t)) - Kd(t) * Id(V_{wfm1}(t)) - Igc(V_{wfm1}(t)) - Idie(V_{wfm1}(t))$$

$$0 = Ku(t) * Iu(V_{wfm2}(t)) + Ipc(V_{wfm2}(t)) - Kd(t) * Id(V_{wfm2}(t)) - Igc(V_{wfm2}(t)) - Idie(V_{wfm2}(t))$$

Where Idie(t) can be obtained by VT waveform and *_fixtures.
(Refer http://www.vhdl.org/pub/ibis/summits/sep07a/chen.pdf)

Solution of two unknowns : Ku(t) , Kd(t) i.e. scaling coefficients of PU, PD

Description of Test Example

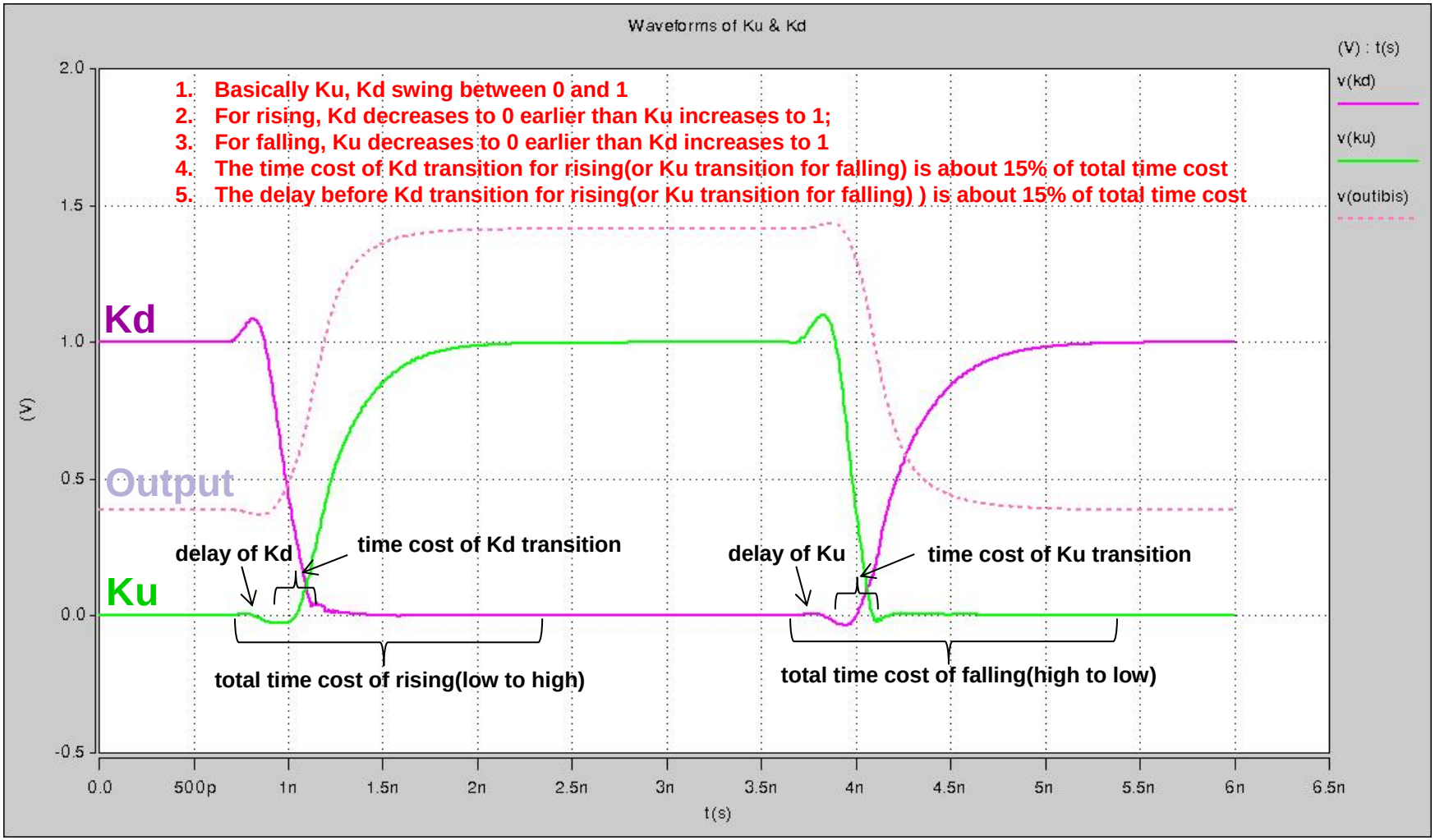
```
Model_type      I/O
|
Vinl    = 0.650V
Vinh    = 1.150V
Vmeas   = 0.900V
Vref    = 0.900V
Cref    = 0.000pF
Rref    = 25.000Ohm
|                    typ           min           max
C_comp               2.911pF       2.841pF       2.984pF
[Voltage Range]      1.800V        1.700V        1.900V
[Temperature Range]  25.0          85.0          0.0
|*********************************************************************************
[Pulldown]
  …
[Pullup]
  …
[GND Clamp]
  …
[POWER Clamp]
  …
[Ramp]
R_load = 25.000Ohm
|            typ                  min                  max
dV/dt_r   0.532V/152.000ps    0.441V/172.000ps    0.600V/138.000ps
dV/dt_f   0.532V/328.000ps    0.441V/372.000ps    0.600V/296.000ps
```

```
[Rising Waveform]
V_fixture = 0.000V
V_fixture_min = 0.000V
V_fixture_max = 0.000V
R_fixture = 25.000Ohm
L_fixture = 0.000nH
C_fixture = 0.000pF
|
[Rising Waveform]
V_fixture = 0.900V
V_fixture_min = 0.850V
V_fixture_max = 0.950V
R_fixture = 25.000Ohm
L_fixture = 0.000nH
C_fixture = 0.000pF
|
[Rising Waveform]
V_fixture = 1.800V
V_fixture_min = 1.700V
V_fixture_max = 1.900V
R_fixture = 25.000Ohm
L_fixture = 0.000nH
C_fixture = 0.000pF
```

```
[Falling Waveform]
V_fixture = 0.000V
V_fixture_min = 0.000V
V_fixture_max = 0.000V
R_fixture = 25.000Ohm
L_fixture = 0.000nH
C_fixture = 0.000pF
|
[Falling Waveform]
V_fixture = 0.900V
V_fixture_min = 0.850V
V_fixture_max = 0.950V
R_fixture = 25.000Ohm
L_fixture = 0.000nH
C_fixture = 0.000pF
|
[Falling Waveform]
V_fixture = 1.800V
V_fixture_min = 1.700V
V_fixture_max = 1.900V
R_fixture = 25.000Ohm
L_fixture = 0.000nH
C_fixture = 0.000pF
```

- **For 2EQ/2UK algorithm, VT waveforms with V_fixture = 0v and 1.8v are used**
- **For Single VT waveform try, the VT waveform with V_fixture=0.9v is used**
- **In later slides, the same model is used**

2EQ/2UK solutions



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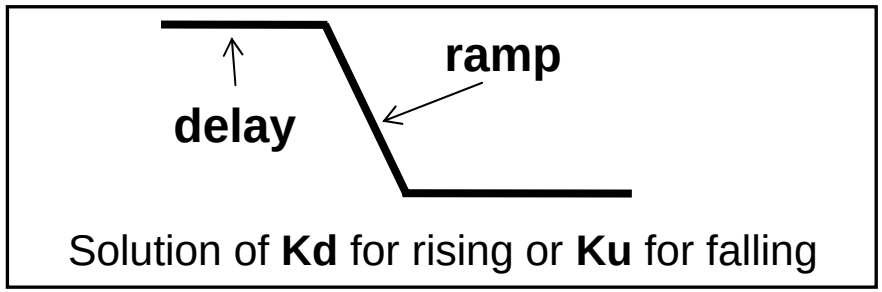
Two Methods to Solve Single VT

- Method 1: Experiential Way

- For rising:
  - construct solution of **Kd** as simple PWL
  - computing **Ku** by the single VT waveform and **Kd**
- For falling:
  - construct solution of **Ku** as simple PWL
  - computing **Kd** by the single VT waveform and **Ku**

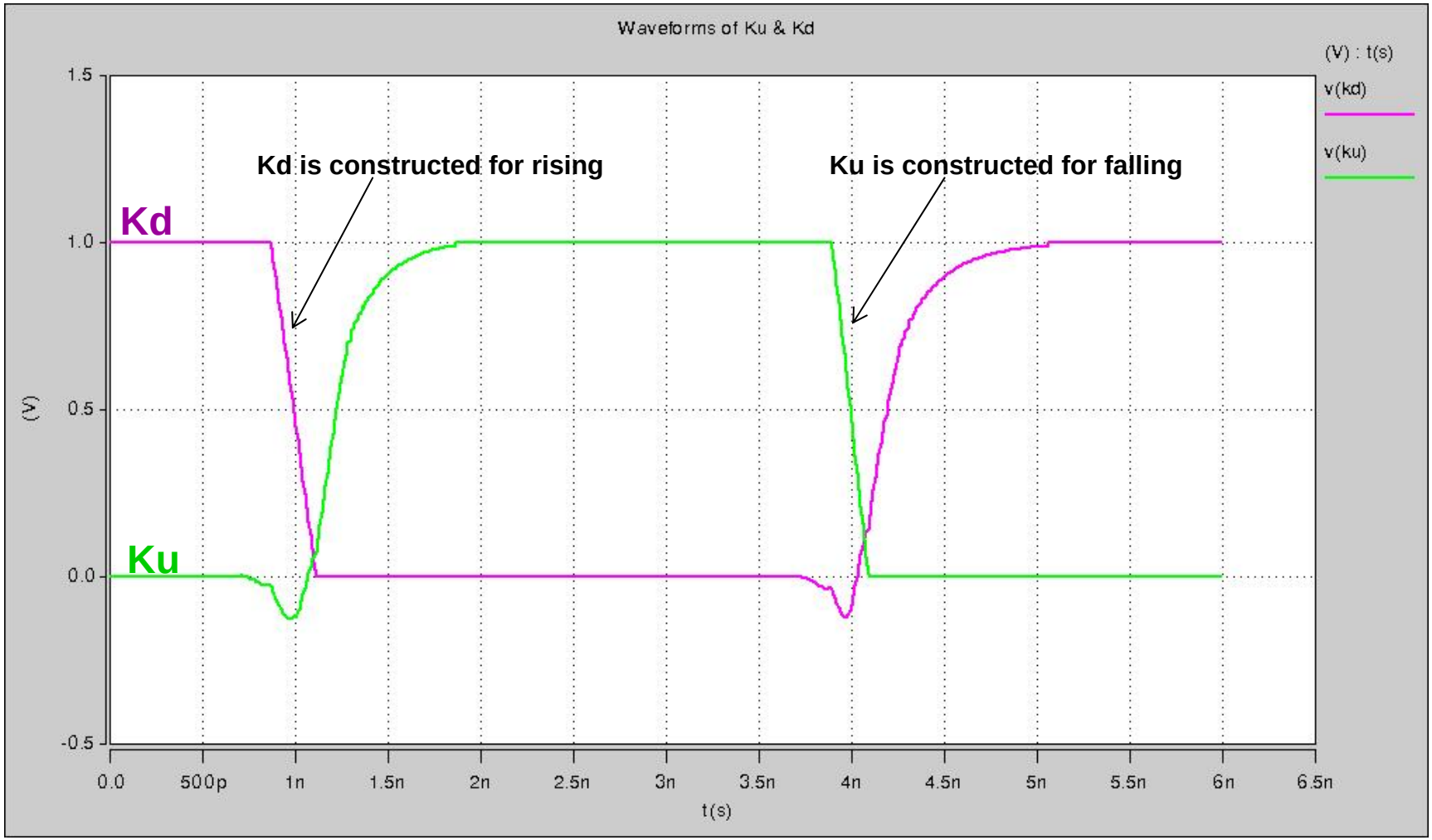


Solution of **Kd** for rising or **Ku** for falling

Note of two key values in PWL - **delay** and **ramp:**

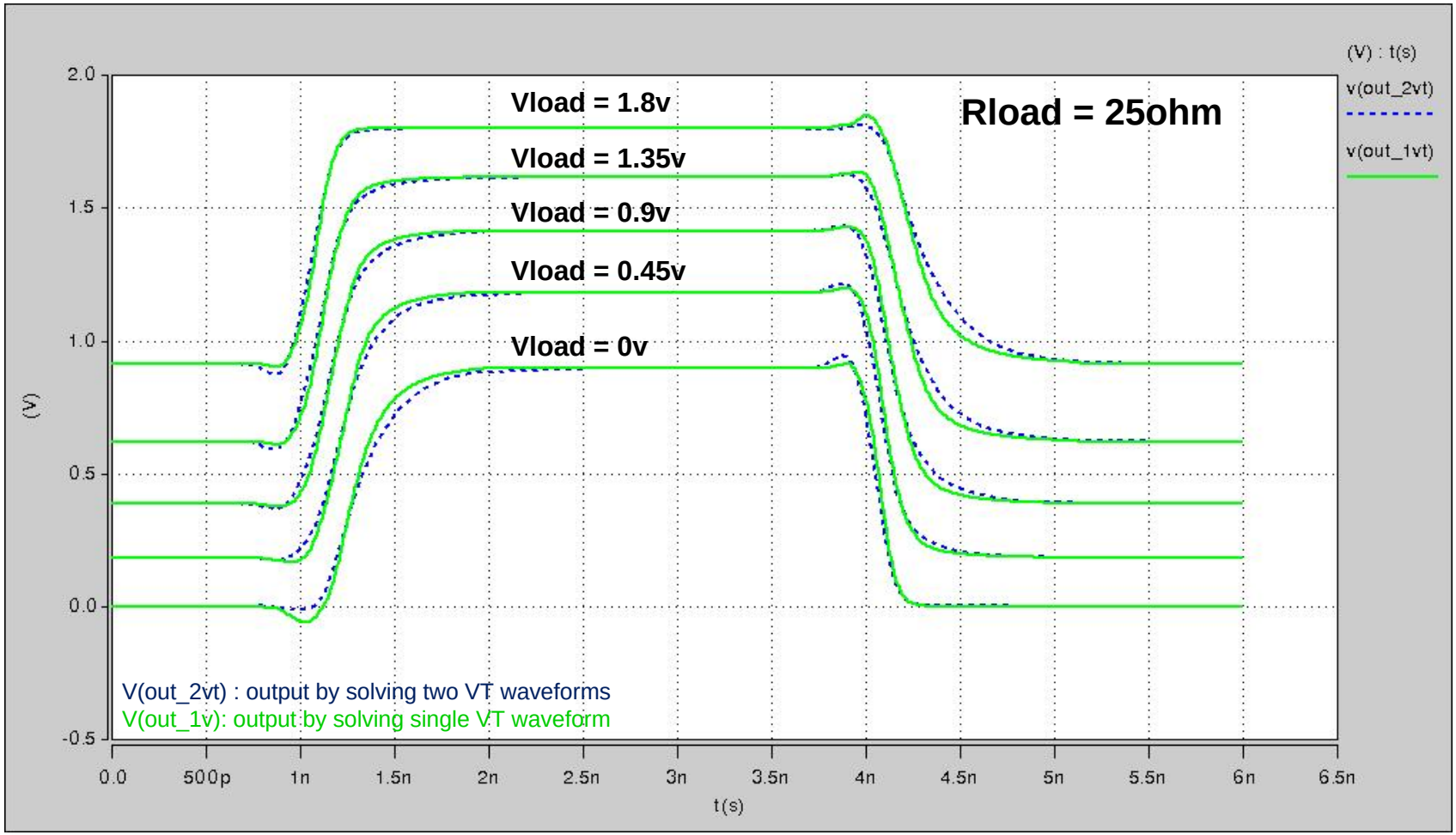
- They can be tuned well to get proper percent value of total transition time. E.g. Both are15% in the test case.
- But It's hard to apply this fixed value to all IBIS models

Solution by Method 1



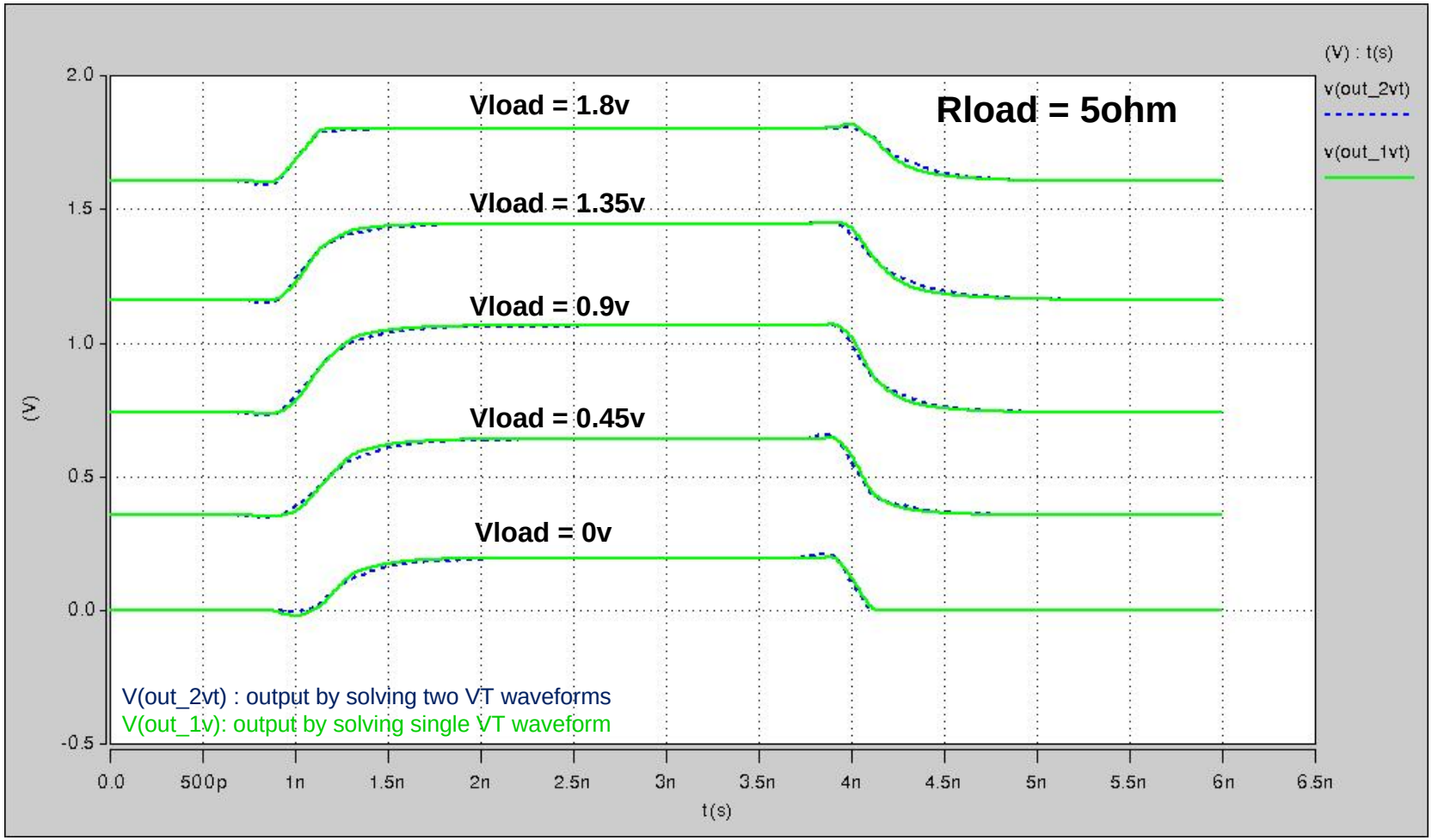
Buffer Output by Method 1

- Loaded In Series with R and V (1)



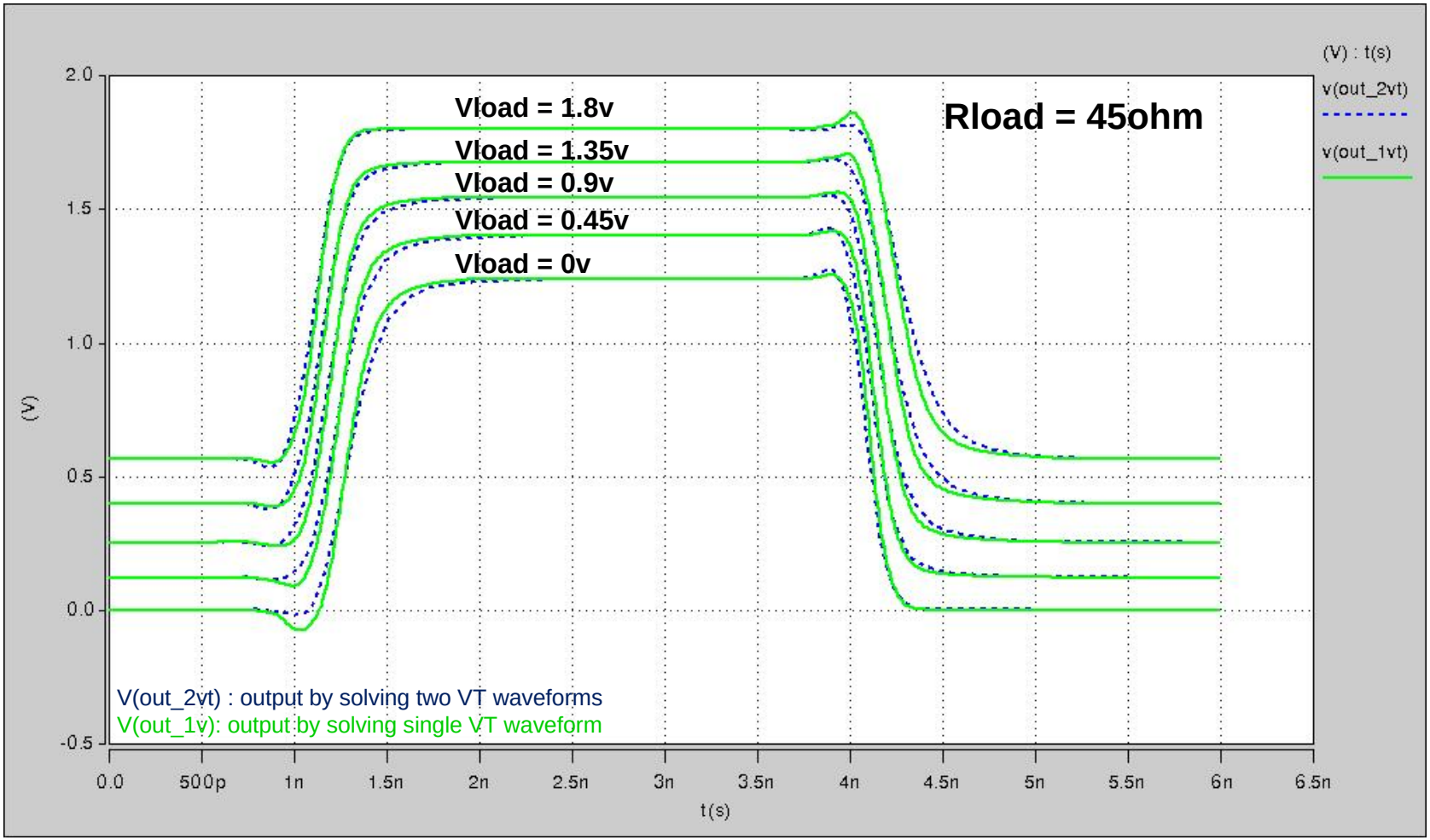
Buffer Output by Method 1

- Loaded In Series with R and V (2)



Buffer Output by Method 1

- Loaded In Series with R and V (3)



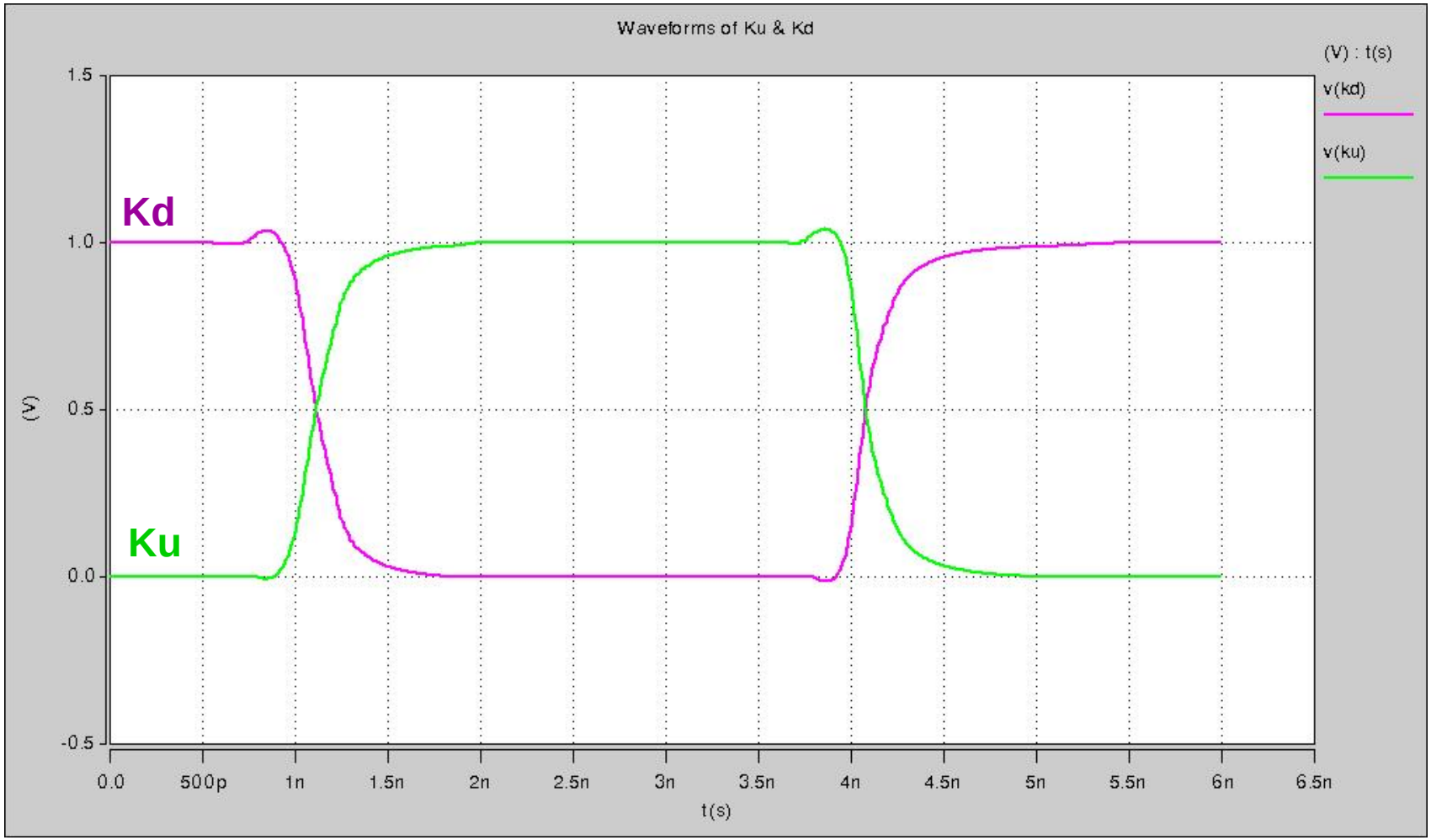
Two Methods to Solve Single VT

- Method 2: Impose Constraint

A simple constraint is imposed, with formula:

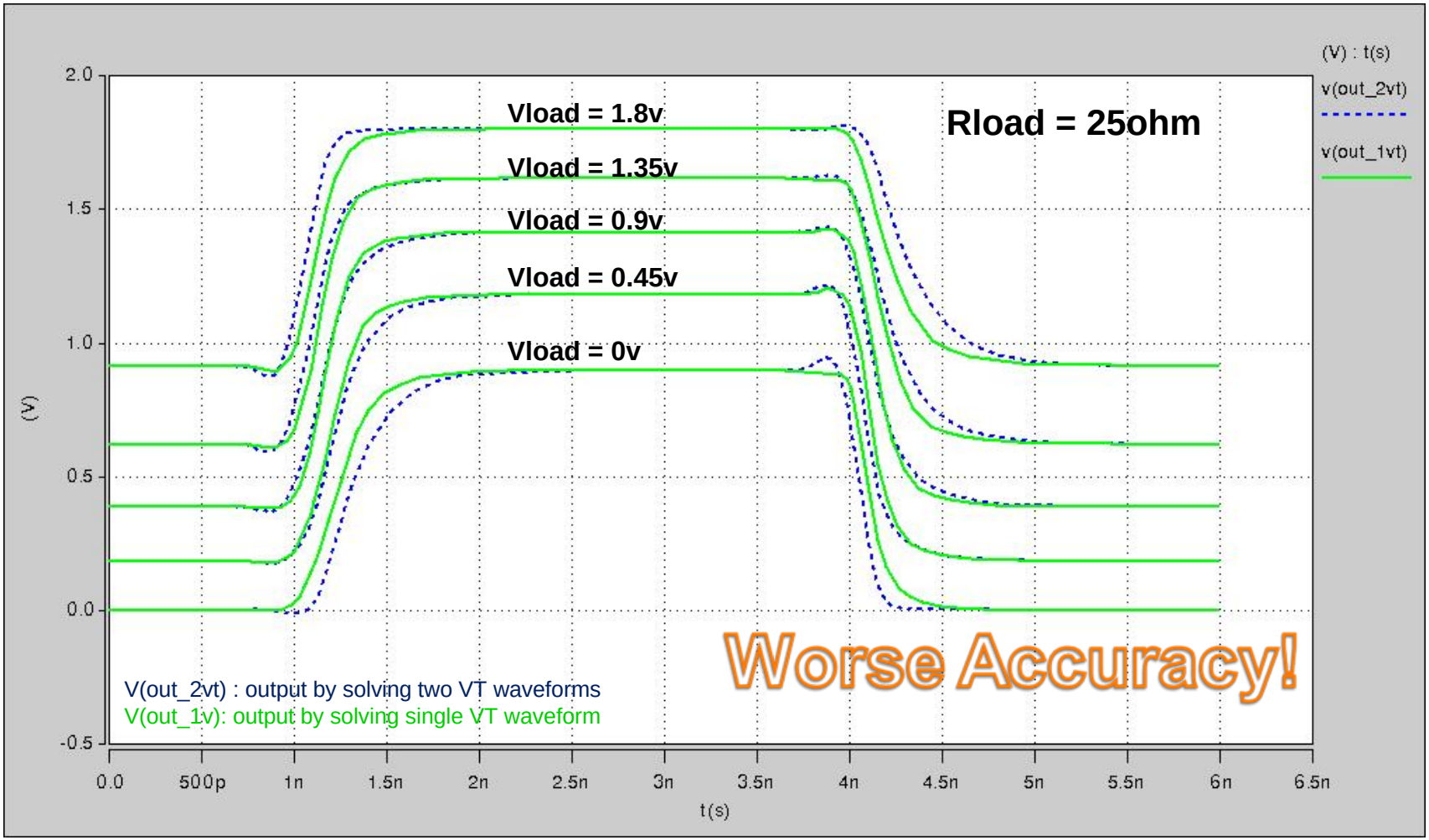
Ku + Kd = 1

Solution by Method 2



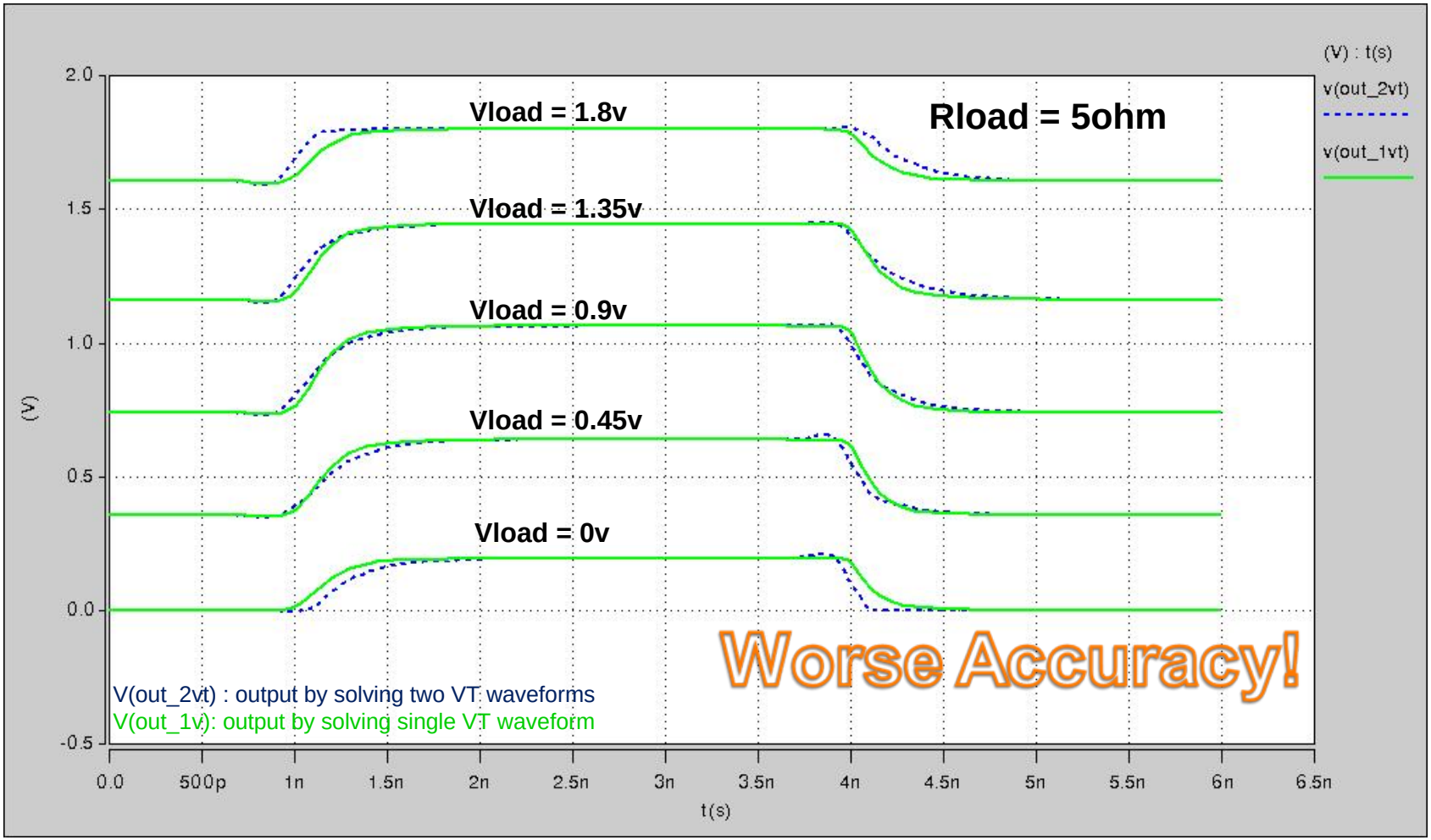
Buffer Output by Method 2

- Loaded In Series with R and V (1)



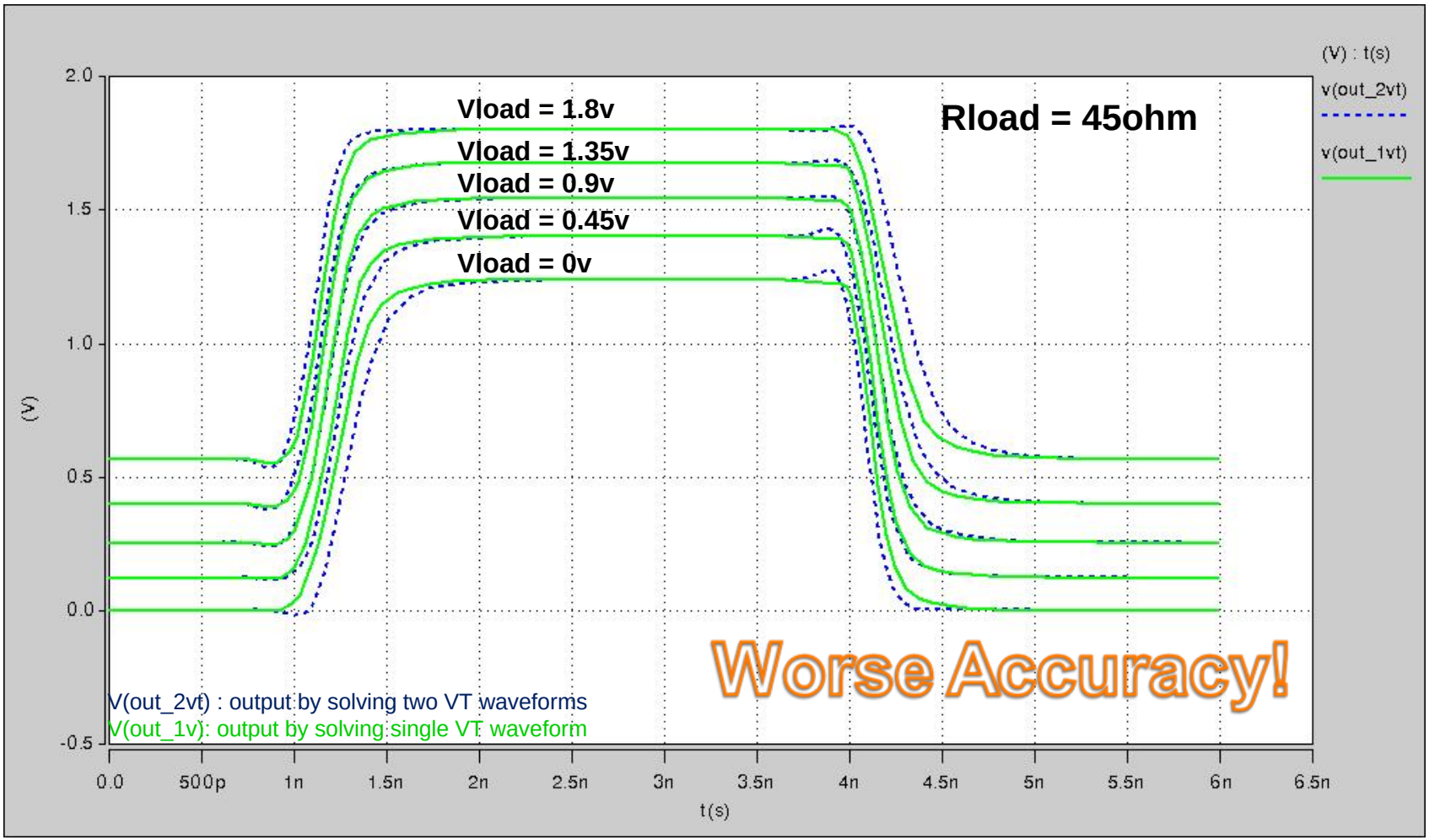
Buffer Output by Method 2

- Loaded In Series with R and V (2)



Buffer Output by Method 2

- Loaded In Series with R and V (3)



Comparison of Two Methods

1. Experiential Way
   - Better accuracy if constructed PWL is tuned well
   - Hard to find a general well-tuned PWL for all IBIS models
2. Impose Constraint
   - Worse Accuracy especially when loading is far way from R_fixture/V_fixture of VT waveform in model.
   - It's a general method and easy to implement

Note:

From testing, more cases show better accuracy with method 1, even with fixed percent values of delay and ramp w.r.t total transition time

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Conclusions

- It’s not easy to find a general method to get accurate enough solution for all IBIS model with single VT waveform.
- For more cases, Method 1(experiential way) with fixed percent of delay and ramp time can get better solution than Method 2(impose constraint)
- Maybe we can offer two tuning parameters for model extractor in IBIS model file in order to improve accuracy of Method 1.

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