CSE464
Bergeron method

Spring, 2005

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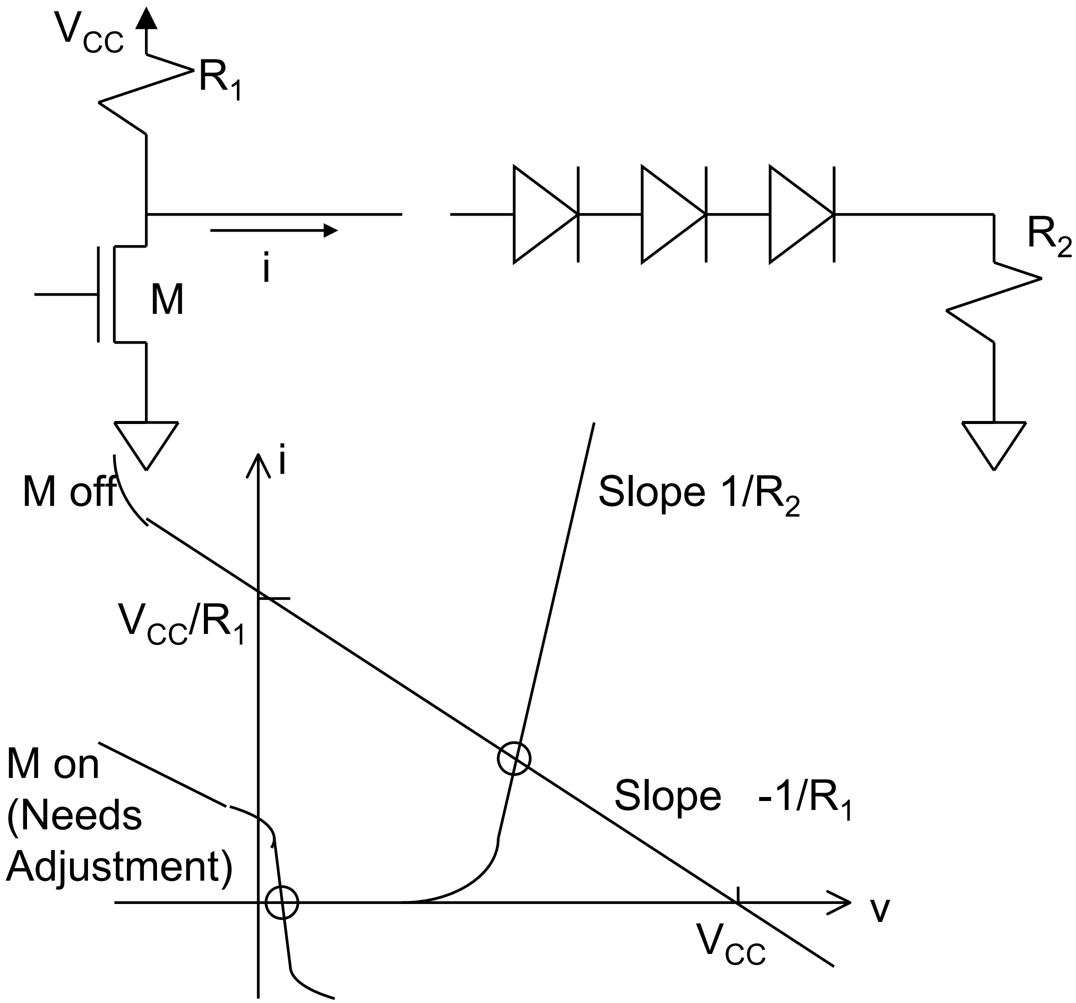
Bergeron Method (Graphical)

- Originally applied to study water hammer in hydralic systems.
- Non-linear systems are difficult to handle analytically.
- Can be considered graphical solution for reflection coefficient, or application of load line and t-line output characteristic.
- *You must be able to determine circuit characteristics (V-I plots).*
- Be careful with step function (easier to analyze) vs non-zero rise time (realistic). Difference is small with linear system, but can be very important for non-linear system.

Graphical Procedure in General

- Plot output characteristic of driver
- Plot input characteristic of receiver
- Find intersection
  - Each plot represents all allowed or possible V-I combinations
  - The intersection is the only possible V-I combination for interconnection of driver and receiver
  - For positive resistance devices there must be exactly one intersection

Graphical Solution: Simple Example



Hints

- Elements in series: add voltages
- Elements in parallel: add currents
- If slope of output characteristic is positive check your work (this would be negative resistance)
- If slope of input characteristic is negative check your work (this would be negative resistance)
- Pick scale so 1/Zo has slope 1, -1/Zo has slope -1.
  - Easier plotting since lines are at 45 degrees
  - More accurate plots, not compressed along one axis

Equations Justifying Bergeron's Method

$$V(x,t)+Z_o\cdot I(x,t)=V_f(t-\frac{x}{v})+V_r(t+\frac{x}{v})+\frac{Z_o}{Z_o}(V_f(t-\frac{x}{v})-V_r(t+\frac{x}{v}))$$

$$V(x,t)+Z_o\cdot I(x,t)=2\cdot V_f(t-\frac{x}{v})$$

Constant traveling from left to right

$$V(x,t)-Z_o\cdot I(x,t)=2\cdot Vr(t+\frac{x}{v})$$

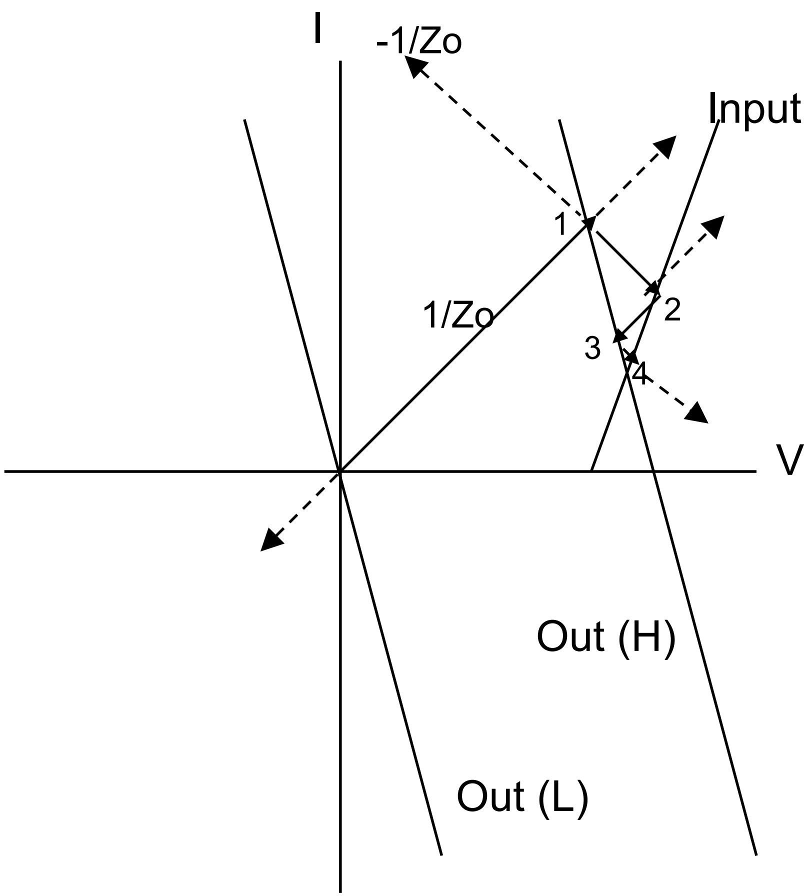
Constant traveling from right to left

If we know $V(x,t)+Zo\cdot I(x,t)$ At x=0, then we know its value at x=l, a time l/v later

Similarly in reverse direction

Simple Example

- Vs=0V to 1V step
- Rs=20 Ohms
- Zo=50 Ohms
- Reciever is diode with forward voltage of 0.8V, series resistance of 20 Ohms.

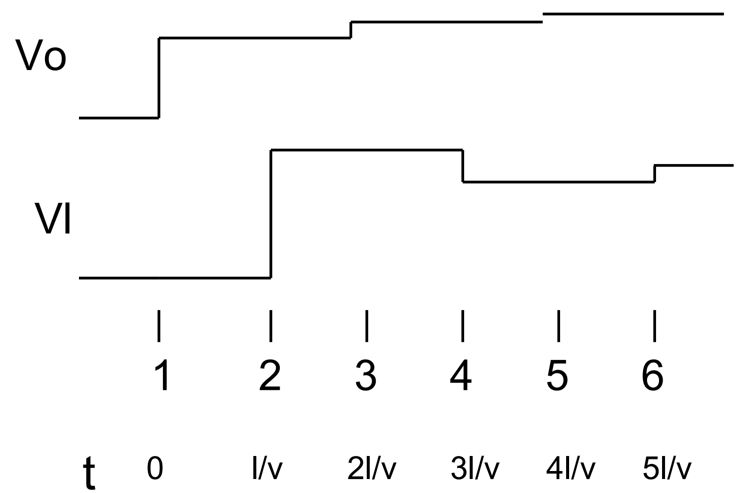


1. Vo(0+)

2. Vl(l/v +)

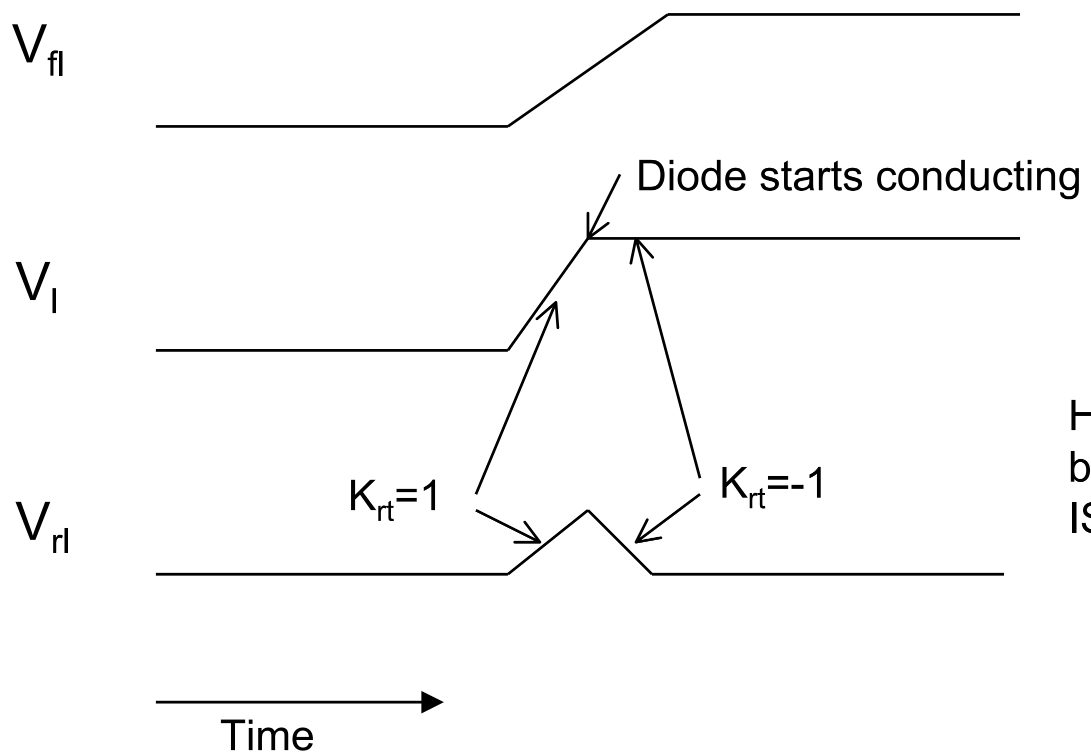
3. Vo(2l/v +)

4. Vl(3l/v +)



Finite Rise-Time Signal and Diode-Clamp Termination

Ideal diode clamp, infinite resistance until conducting, then zero resistance



Half amplitude wave reflected back to source, can give severe ISI