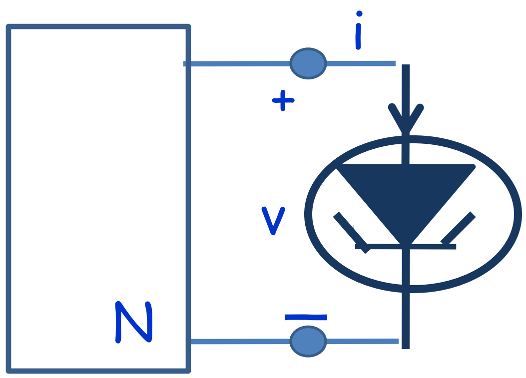
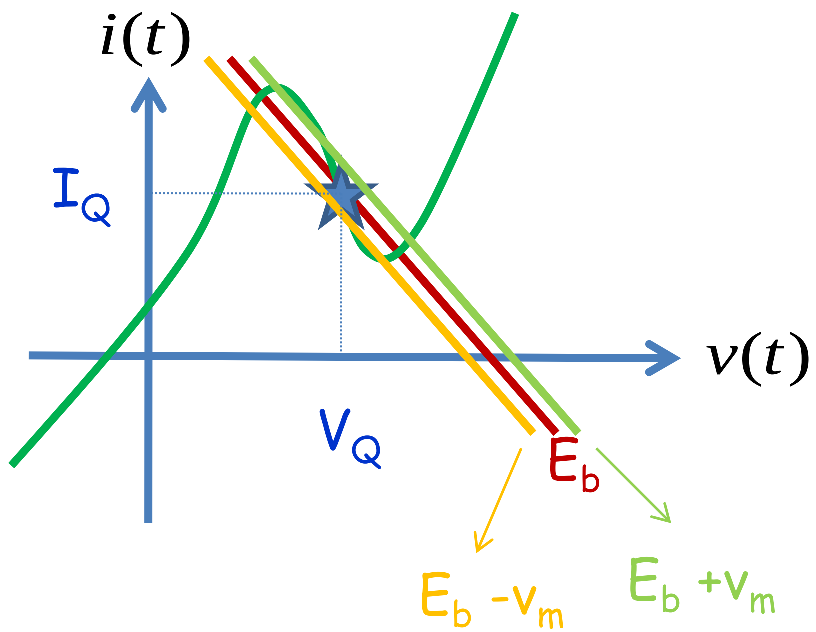
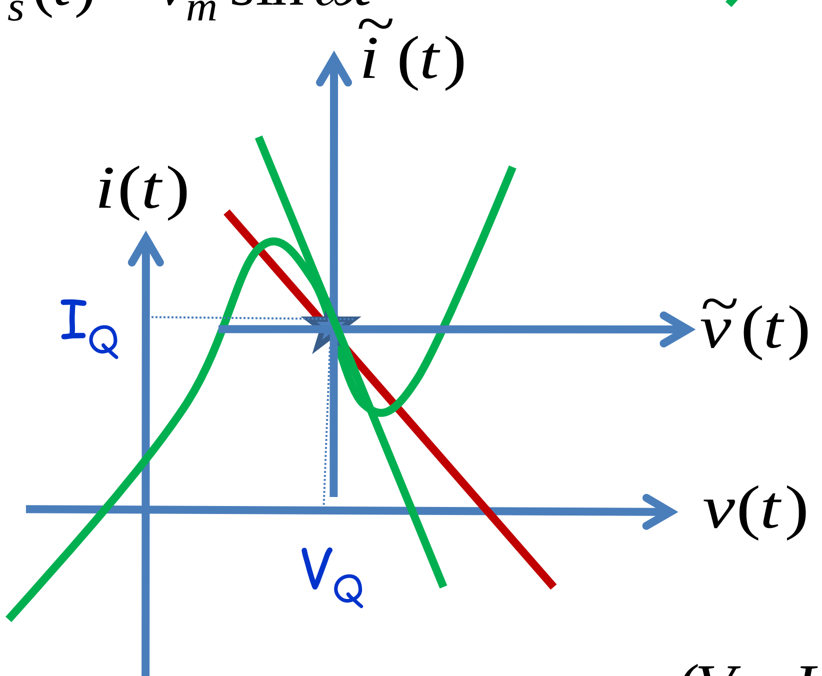
# Küçük İşaret Analizi




$$v_s(t) = v_m \sin \omega t$$




- Çalışma noktasını belirle. Nasıl?
- Lineer olmayan elemanın çalışma noktası civarında lineer eşdeğerini belirle. Nasıl?

$$(V_Q, I_Q) \qquad (\tilde{v}(t), \tilde{i}\,(t))$$

$$v(t) = V_Q + \tilde{v}(t)$$

$$i(t) = I_Q + \tilde{i}\,(t)$$

# Lineer Eşdeğer

Varsayım: $v_m << E_b \Rightarrow \tilde{v}(t) << V_Q$

Hatırlatma: Taylor Serisi

$$f(x) \cong f(x)\big|_{x=x_a} + f'(x)\big|_{x=x_a}(x-x_a) + \frac{1}{2} f''(x)\big|_{x=x_a}(x-x_a)^2 + \ldots$$

$$i(t) \cong \hat{i}(V_Q) + \left.\frac{d\hat{i}}{dv}\right|_{v=V_Q} (v(t) - V_Q)$$

$$i(t) - \hat{i}(V_Q) \cong \left.\frac{d\hat{i}}{dv}\right|_{v=V_Q} (v(t) - V_Q)$$

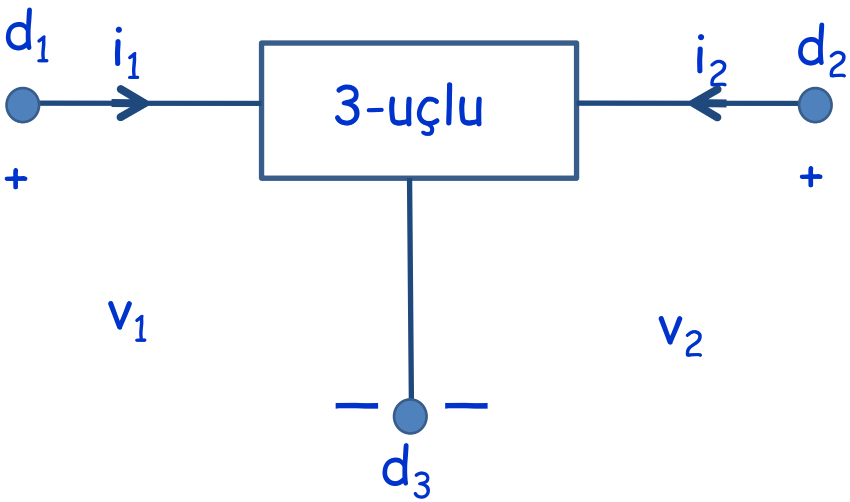
$$i(t) - I_Q \cong \left.\frac{d\hat{i}}{dv}\right|_{v=V_Q} (v(t) - V_Q)$$

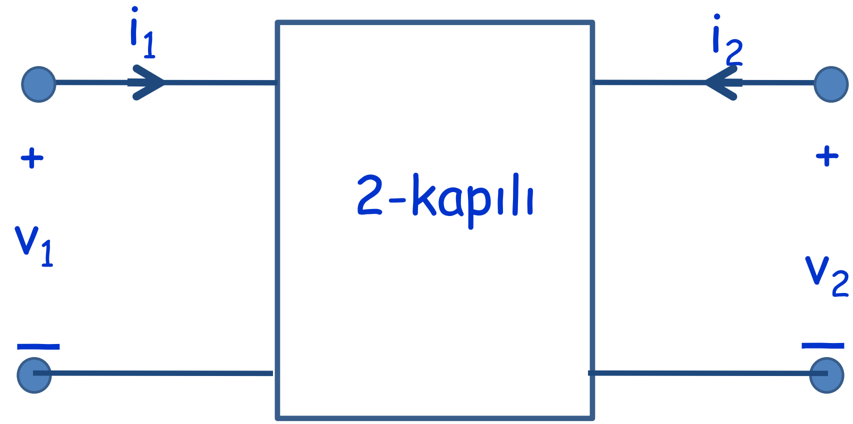
Küçük işaret iletkenliği

$$\tilde{i}(t) \cong \left.\frac{d\hat{i}}{dv}\right|_{v=V_Q} \tilde{v}(t) \quad \Rightarrow \quad \tilde{i}(t) \cong G\tilde{v}(t)$$

# Çok-Uçlu Direnç Elemanları

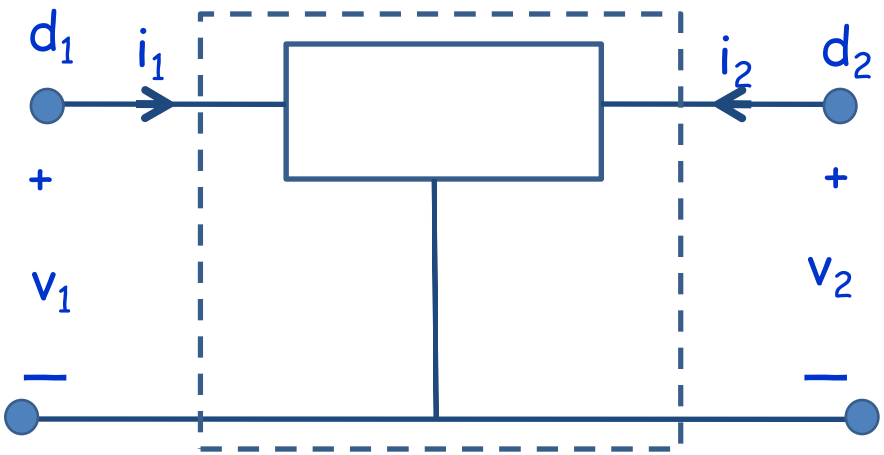
- 2-kapılı 3-uçlu




- 3-uçluyu tanımlayan uç büyüklükleri $v_1$ ,$v_2$ , $i_1$ , $i_2$

- 2-kapılıyı tanımlayan kapı büyüklükleri $v_1$ ,$v_2$ , $i_1$ , $i_2$




$$v = \begin{bmatrix} v_1 \\ v_2 \end{bmatrix}, \quad i = \begin{bmatrix} i_1 \\ i_2 \end{bmatrix}$$

$$R_R = \{(v_1, v_2, i_1, i_2) : \; f_1(v_1, v_2, i_1, i_2) = 0, \; f_2(v_1, v_2, i_1, i_2) = 0\}$$

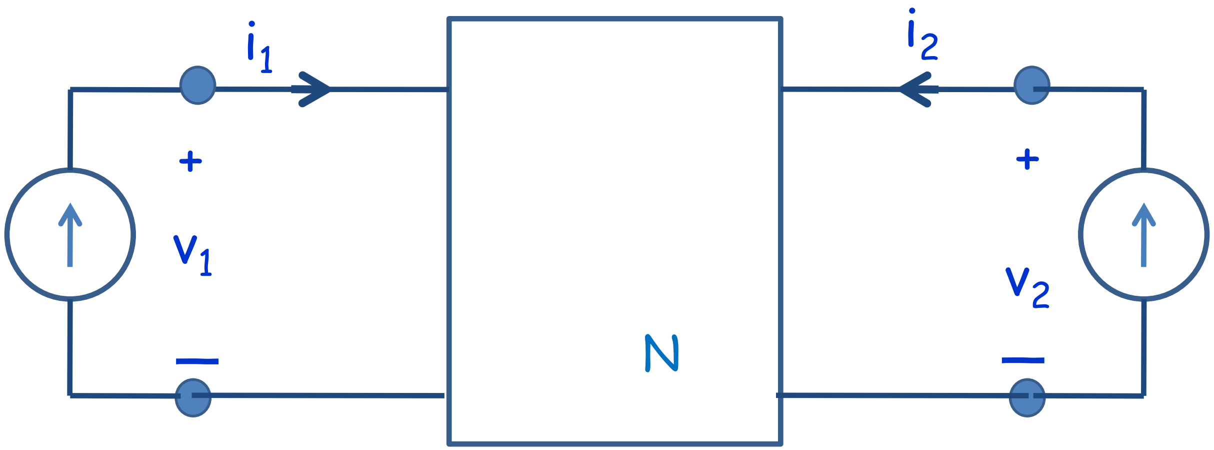
- 2-kapılı direnç elemanlarını tanımlamak için 4 büyüklük ($v_1$ ,$v_2$ , $i_1$ , $i_2$ ) ve iki denklem $f_1(v_1, v_2, i_1, i_2)=0$ $f_2(v_1, v_2, i_1, i_2)=0$ var. Acaba bir iki kapılıya karşı düşen kaç gösterim var?

- iki değişkeni diğer ikisi cinsinden yazacağımızı düşünelim:

$$C_2^4 = \frac{4!}{2!(4-2)!} = 6$$

Lineer 2-kapılılar için 6 gösterim:

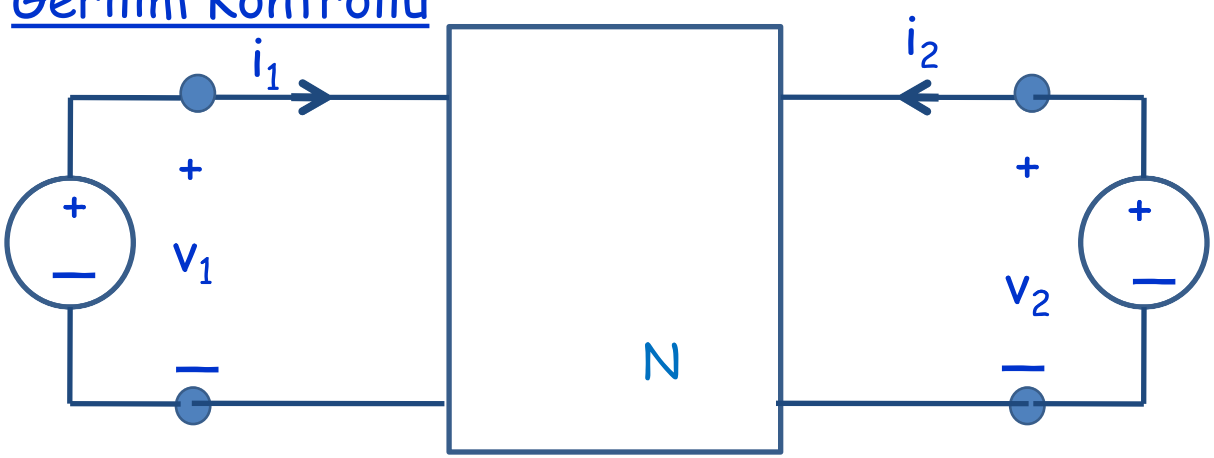
Akım Kontrollü




$$\begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} \\ r_{21} & r_{22} \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \end{bmatrix}$$

$$v = R\,i$$

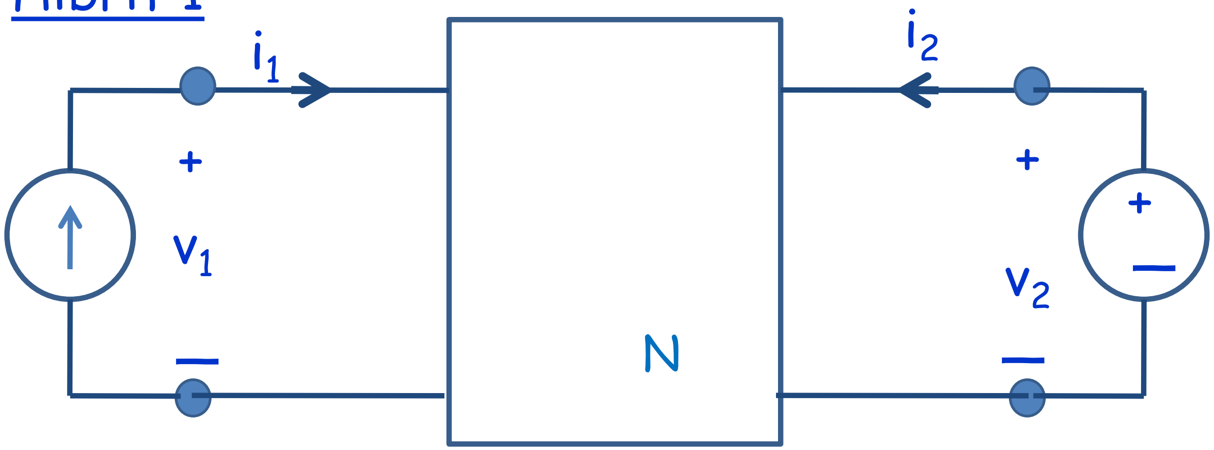
Gerilim Kontrollü




$$\begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix}$$

$$i = G\,v$$

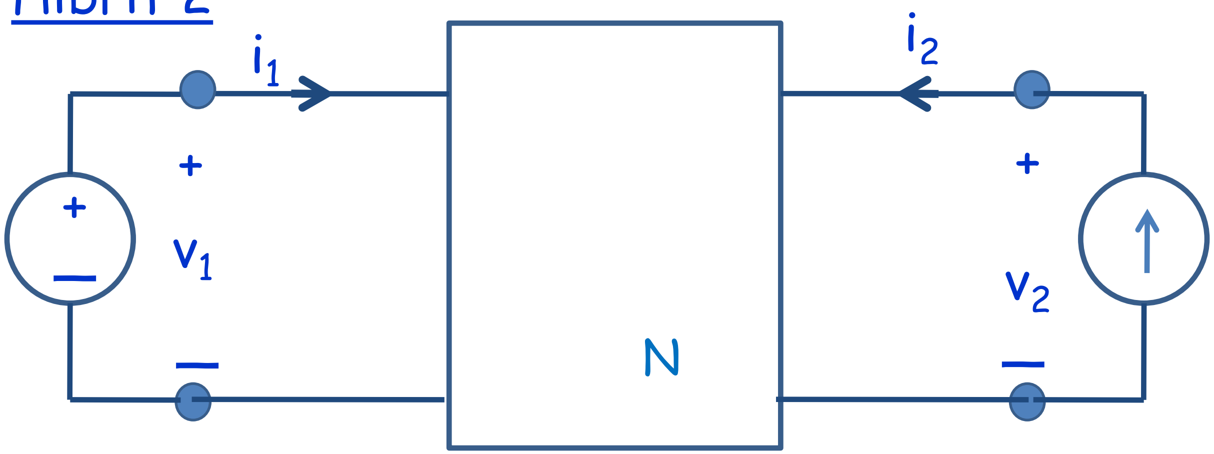
## Hibrit 1




$$\begin{bmatrix} v_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} i_1 \\ v_2 \end{bmatrix}$$

$$\begin{bmatrix} v_1 \\ i_2 \end{bmatrix} = H \begin{bmatrix} i_1 \\ v_2 \end{bmatrix}$$

## Hibrit 2




$$\begin{bmatrix} i_1 \\ v_2 \end{bmatrix} = \begin{bmatrix} \tilde{h}_{11} & \tilde{h}_{12} \\ \tilde{h}_{21} & \tilde{h}_{22} \end{bmatrix} \begin{bmatrix} v_1 \\ i_2 \end{bmatrix}$$

$$\begin{bmatrix} i_1 \\ v_2 \end{bmatrix} = \tilde{H} \begin{bmatrix} v_1 \\ i_2 \end{bmatrix}$$

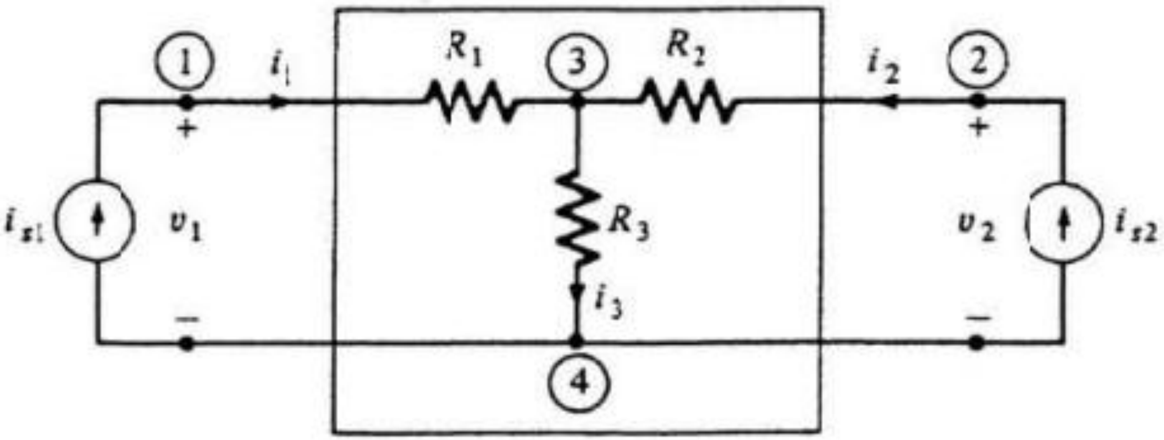
## Transmisyon 1

$$\begin{bmatrix} v_1 \\ i_1 \end{bmatrix} = \begin{bmatrix} t_{11} & t_{12} \\ t_{21} & t_{22} \end{bmatrix} \begin{bmatrix} v_2 \\ -i_2 \end{bmatrix}$$

## Transmisyon 2

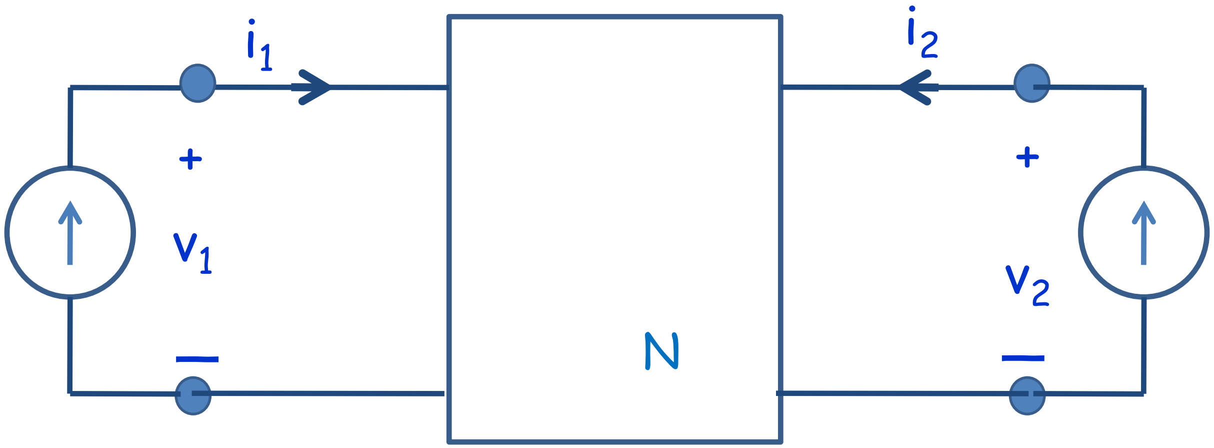
$$\begin{bmatrix} v_2 \\ -i_2 \end{bmatrix} = \begin{bmatrix} \tilde{t}_{11} & \tilde{t}_{12} \\ \tilde{t}_{21} & \tilde{t}_{22} \end{bmatrix} \begin{bmatrix} v_1 \\ i_1 \end{bmatrix}$$

# Akım kontrollü gösterimini elde ediniz



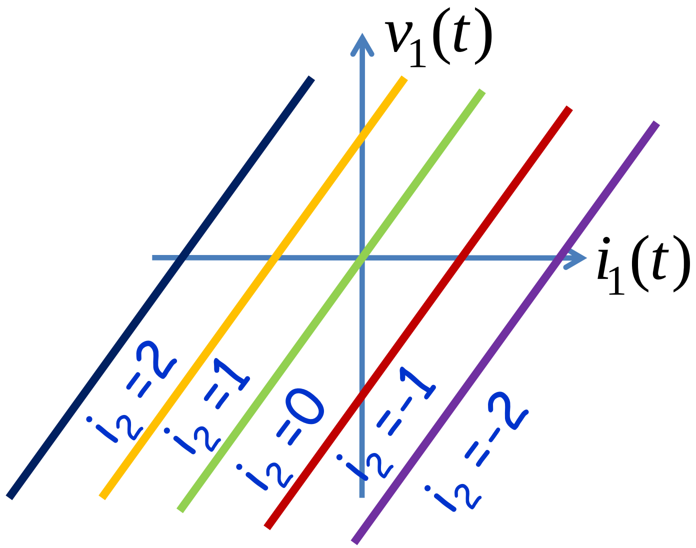

L.O. Chua, C.A. Desoer, S.E. Kuh. “Linear and Nonlinear Circuits”, Mc.Graw Hill, 1987, New York

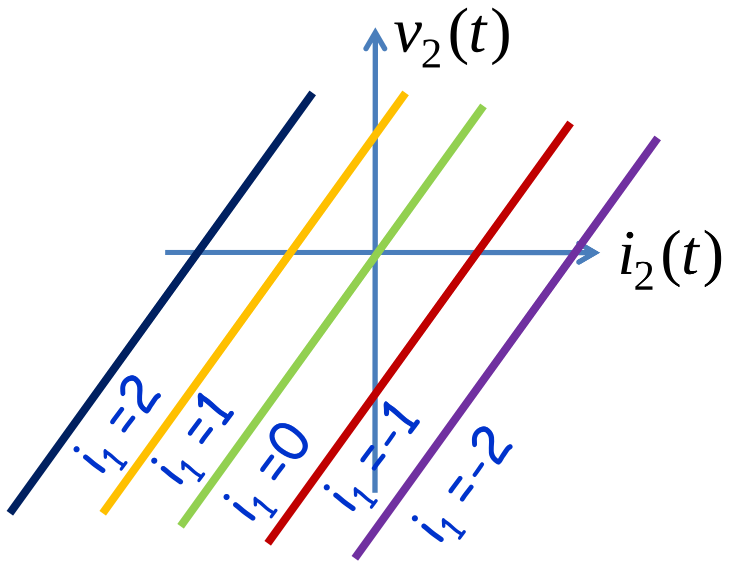
# Akım Kontrollü




$$\begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} \\ r_{21} & r_{22} \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \end{bmatrix}$$

$$v = R\,i$$



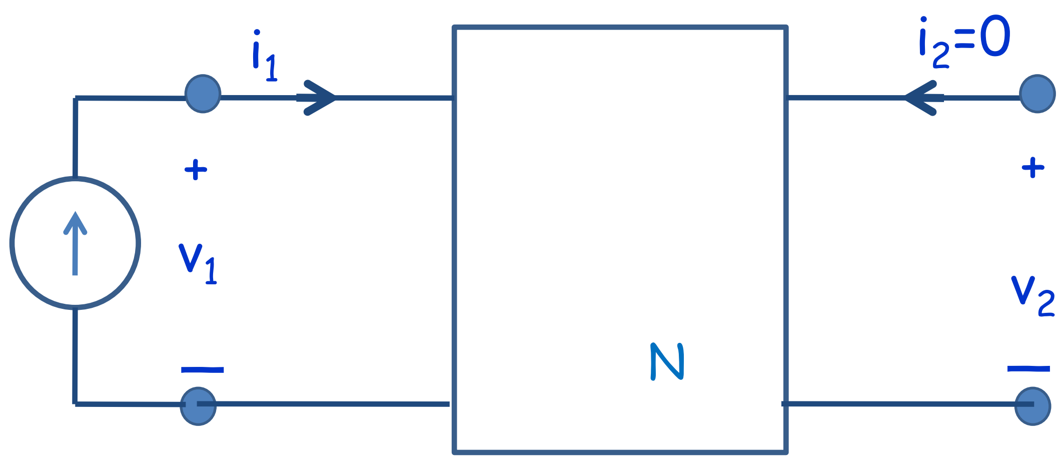



$r_{11}$ 'i elde etmek için devrede nasıl bir değişiklik yapmamızı önerirsiniz?

$$\begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} \\ r_{21} & r_{22} \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \end{bmatrix}$$

$$v_1 = r_{11} i_1 + r_{12} i_2$$

$$r_{11} = \left. \frac{v_1}{i_1} \right|_{i_2=0}$$

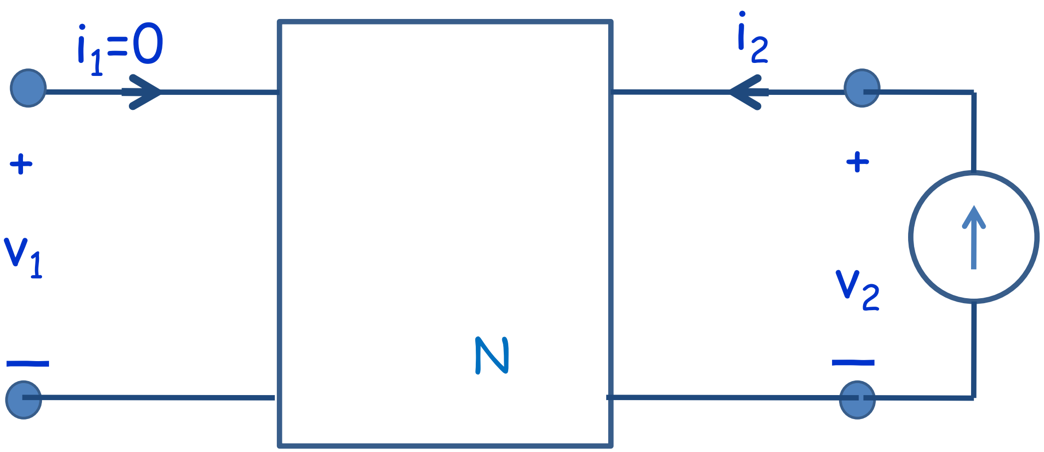



$r_{21}$ için öneriniz nedir?

$$v_2 = r_{21} i_1 + r_{22} i_2 \qquad r_{21} = \left. \frac{v_2}{i_1} \right|_{i_2=0}$$

$r_{12}$ için öneriniz nedir?

$$v_1 = r_{11} i_1 + r_{12} i_2 \qquad r_{12} = \left. \frac{v_1}{i_2} \right|_{i_1=0}$$




$r_{22}$ için öneriniz nedir?

$$v_2 = r_{21} i_1 + r_{22} i_2$$

$$r_{22} = \left. \frac{v_2}{i_2} \right|_{i_1=0}$$