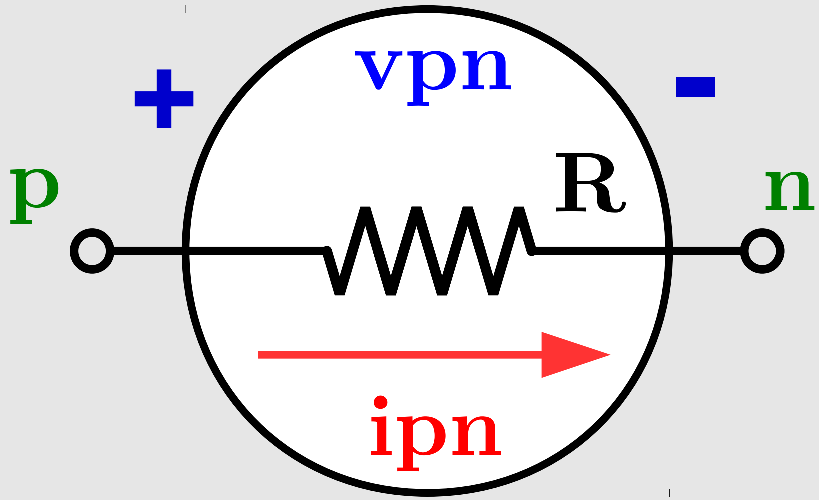
Resistor



name: $\mathbf{myR}$

2 terminals: $\mathbf{p}$, $\mathbf{n}$

branch: $\mathbf{pn}$

I/Os: $\mathbf{ipn}$, $\mathbf{vpn}$

model equation: $\mathbf{ipn} = \frac{\mathbf{vpn}}{\mathbf{R}}$

explicit output: $\mathbf{ipn}$

parameter: $\mathbf{R}$

$$\mathbf{ipn} = \frac{d}{dt}\underbrace{(\ \mathbf{0}\ )}_{\mathbf{qe}} + \underbrace{\frac{\mathbf{vpn}}{\mathbf{R}}}_{\mathbf{fe}}$$

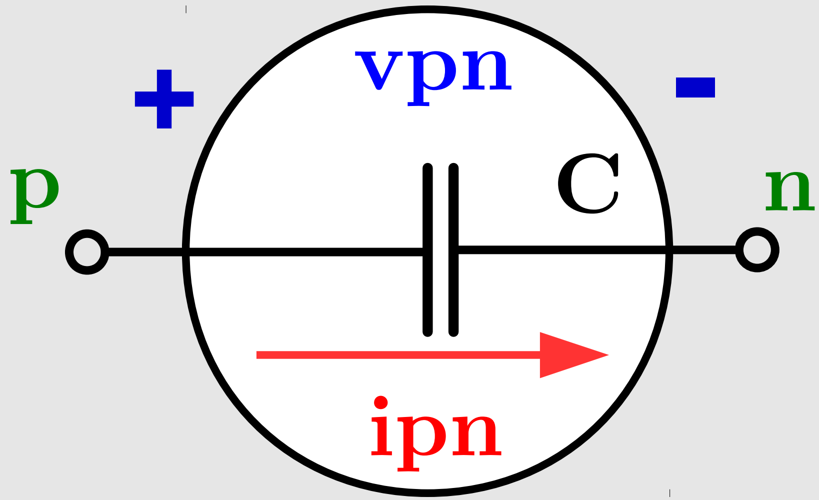
Resistor

1. **define parameter**
2. **fill in functions**

```
function MOD = myR()
    MOD = ee_model();
    MOD = add_to_ee_model(MOD, 'name', 'myR');
    MOD = add_to_ee_model(MOD, 'terminals', {'p', 'n'});
    MOD = add_to_ee_model(MOD, 'explicit_outs', {'ipn'});

    MOD = add_to_ee_model(MOD, 'parms', {'R', 1000.0});

    MOD = add_to_ee_model(MOD, 'fe', @fe);
    MOD = add_to_ee_model(MOD, 'qe', @qe);

    MOD = finish_ee_model(MOD);
end % myR

function out = fe(S)
    v2struct(S);

    ipn_fe = vpn/R;

    out(1, 1) = ipn_fe;
end % fe

function out = qe(S)
    v2struct(S);

    ipn_qe = 0;

    out(1, 1) = ipn_qe;
end % qe
```

$$\mathbf{ipn} = \underbrace{\frac{d}{dt}\left(\mathbf{0}\right)}_{\mathbf{qe}} + \underbrace{\frac{\mathbf{vpn}}{\mathbf{R}}}_{\mathbf{fe}}$$

Capacitor



name: myC

2 terminals: p, n

branch: pn

I/Os: ipn, vpn

model equation: $\mathbf{ipn} = \frac{d}{dt}(\mathbf{C} \cdot \mathbf{vpn})$

explicit output: ipn

parameter: C

$$\mathbf{ipn} = \frac{d}{dt}\underbrace{(\mathbf{C} \cdot \mathbf{vpn})}_{\mathbf{qe}} + \underbrace{\mathbf{0}}_{\mathbf{fe}}$$

Capacitor

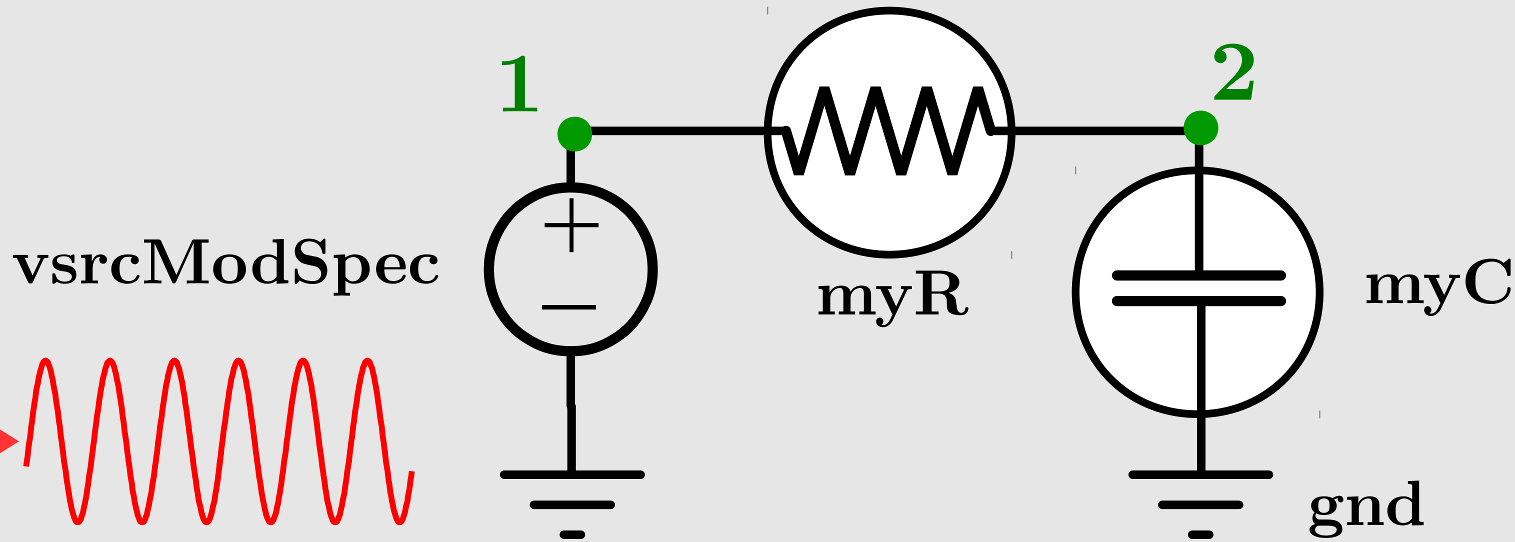
1 **define parameter**

2 **fill in functions**

```
function MOD = myC()
    MOD = ee_model();
    MOD = add_to_ee_model(MOD, 'name', 'myC');
    MOD = add_to_ee_model(MOD, 'terminals', {'p', 'n'});
    MOD = add_to_ee_model(MOD, 'explicit_outs', {'ipn'});

    MOD = add_to_ee_model(MOD, 'parms', {'C', 1e-6});

    MOD = add_to_ee_model(MOD, 'fe', @fe);
    MOD = add_to_ee_model(MOD, 'qe', @qe);

    MOD = finish_ee_model(MOD);
end % myC

function out = fe(S)
    v2struct(S);

    ipn_fe = 0;

    out(1, 1) = ipn_fe;
end % fe

function out = qe(S)
    v2struct(S);

    ipn_qe = C*vpn;

    out(1, 1) = ipn_qe;
end % qe
```

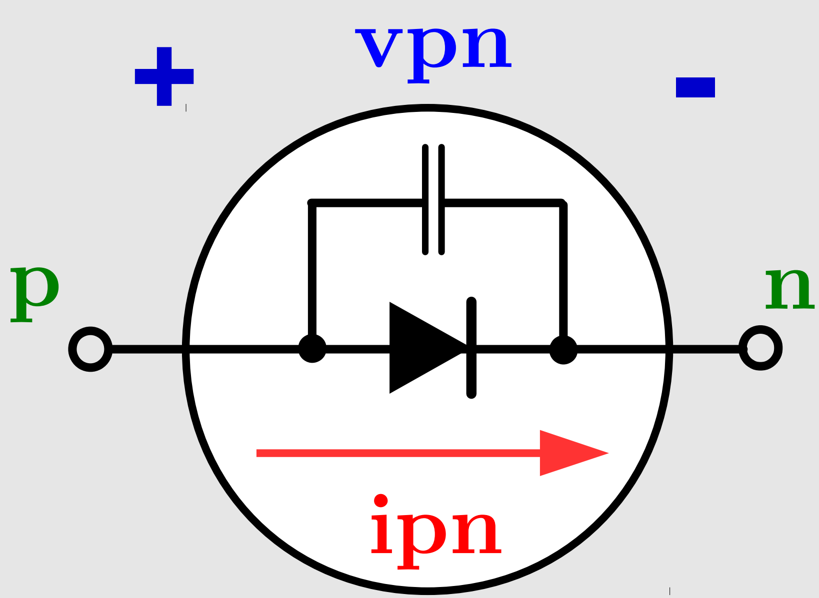
$$\mathbf{ipn} = \frac{d}{dt}\underbrace{(\mathbf{C} \cdot \mathbf{vpn})}_{\mathbf{qe}} + \underbrace{\mathbf{0}}_{\mathbf{fe}}$$

RC circuit




```
function cktnetlist = myRC_ckt()
    cktnetlist.cktname = 'myRC_ckt';
    cktnetlist.nodenames = {'1', '2'}; % non-ground nodes
    cktnetlist.groundnodename = 'gnd';

    cktnetlist = add_element(cktnetlist, myR(), 'R1', {'1', '2'}, {{'R', 1000}});
    cktnetlist = add_element(cktnetlist, myC(), 'C1', {'2', 'gnd'}, 1e-6);

    mysinfunc = @(t, args) sin(2*pi*1000*t);

    cktnetlist = add_element(cktnetlist, vsrcModSpec(), 'V1', ...
       {'1', 'gnd'}, {}, {{'DC', 1}, {'AC', 1}, {'TRAN', mysinfunc, []}});
end % myRC_ckt
```

Diode



name: $\mathbf{diodeC}$

2 terminals: $\mathbf{p}, \mathbf{n}$

branch: $\mathbf{pn}$

I/Os: $\mathbf{ipn}, \mathbf{vpn}$

model equation: $\mathbf{ipn} = \frac{d}{dt}(\mathbf{C} \cdot \mathbf{vpn}) + I_S \cdot \left(e^{\frac{\mathbf{vpn}}{\mathbf{V_T}}} - 1\right)$

explicit output: $\mathbf{ipn}$

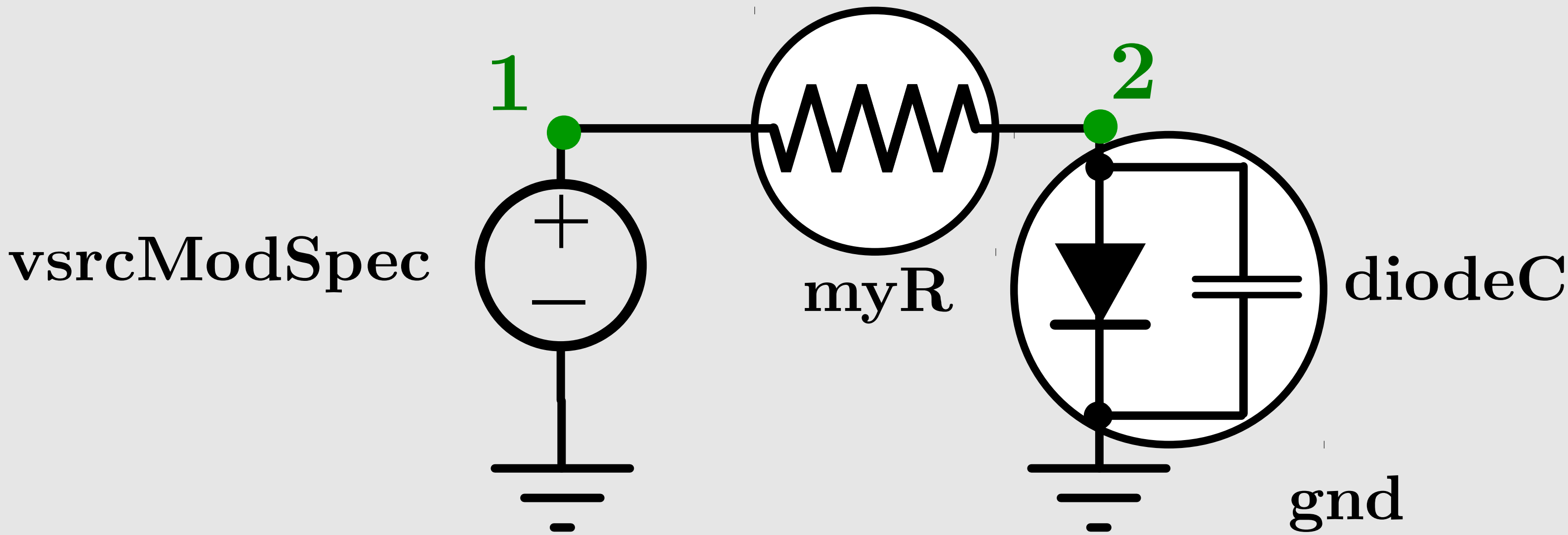
parameters: $\mathbf{C},\ \mathbf{I_S},\ \mathbf{V_T}$

$$\mathbf{ipn} = \frac{d}{dt}(\mathbf{qe}) + \mathbf{fe}$$

$$\mathbf{qe} = \mathbf{C} \cdot \mathbf{vpn}$$

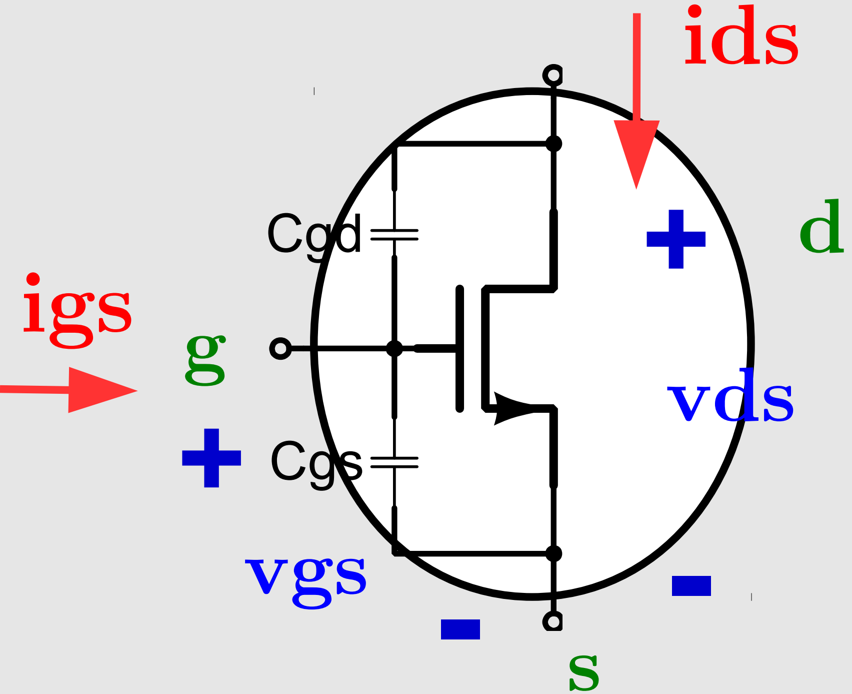
$$\mathbf{fe} = \mathbf{I_S} \cdot \left(\mathbf{e}^{\frac{\mathbf{vpn}}{\mathbf{V_T}}} - \mathbf{1}\right)$$

Vsrc-R-diode circuit




```
function cktnetlist = myR_diodeC_ckt()
    cktnetlist.cktname = 'myR_diodeC_ckt';
    cktnetlist.nodenames = {'1', '2'}; % non-ground nodes
    cktnetlist.groundnodename = 'gnd';

    cktnetlist = add_element(cktnetlist, vsrcModSpec(), 'V1', ...
       {'1', 'gnd'}, {}, {{'DC', 1}});
    cktnetlist = add_element(cktnetlist, myR(), 'R1', {'1', '2'}, {{'R', 1}});
    cktnetlist = add_element(cktnetlist, diodeC(), 'D1', {'2', 'gnd'});
end % myR_diodeC_ckt
```

Schichman-Hodges MOS Model



name: $\mathbf{myNMOS}$

3 terminals: $\mathbf{d}, \mathbf{g}, \mathbf{s}$

branchs: $\mathbf{ds}, \mathbf{gs}$

model equation:

$$\mathbf{ids\_fe} = \begin{cases} 0 & \text{if } \mathbf{vgs} \leq V_{th} \\ \beta \left[(\mathbf{vgs} - V_{th}) - \frac{\mathbf{vds}}{2} \right] \mathbf{vds}, & \text{if } \mathbf{vgs} > V_{th} \text{ and } \mathbf{vgs} < \mathbf{vds} + V_{th} \\ \frac{1}{2} \cdot \beta \cdot (\mathbf{vgs} - V_{th})^2, & \text{if } \mathbf{vds} \geq \mathbf{vgs} - V_{th} \end{cases}$$

$$\mathbf{igs\_fe} = 0$$

explicit output: $[\mathbf{ids}; \mathbf{igs}]$

parameters: $V_{th}, \ \beta, \ \mathbf{Cgs}, \ \mathbf{Cgd}$