

$T := 'T'; v0 := 'v0'; v0 := 1; T := 0.012; r := 1000.; c := 1.0e-6;$

$T$   
 $v0$   
 $1$   
 $0.012$   
 $1000.$   
 $0.0000010$

(1)

Break up the triangle wave into regions

$$vin = \frac{v0 \cdot t}{\left(\frac{T}{4}\right)} \quad 0 < t < \frac{T}{4} \quad vin = -\frac{2 \cdot v0}{\left(\frac{T}{2}\right)} \left(t - \frac{T}{4}\right) + v0 \quad \frac{T}{4} < t < \frac{3T}{4}$$

Write as a function

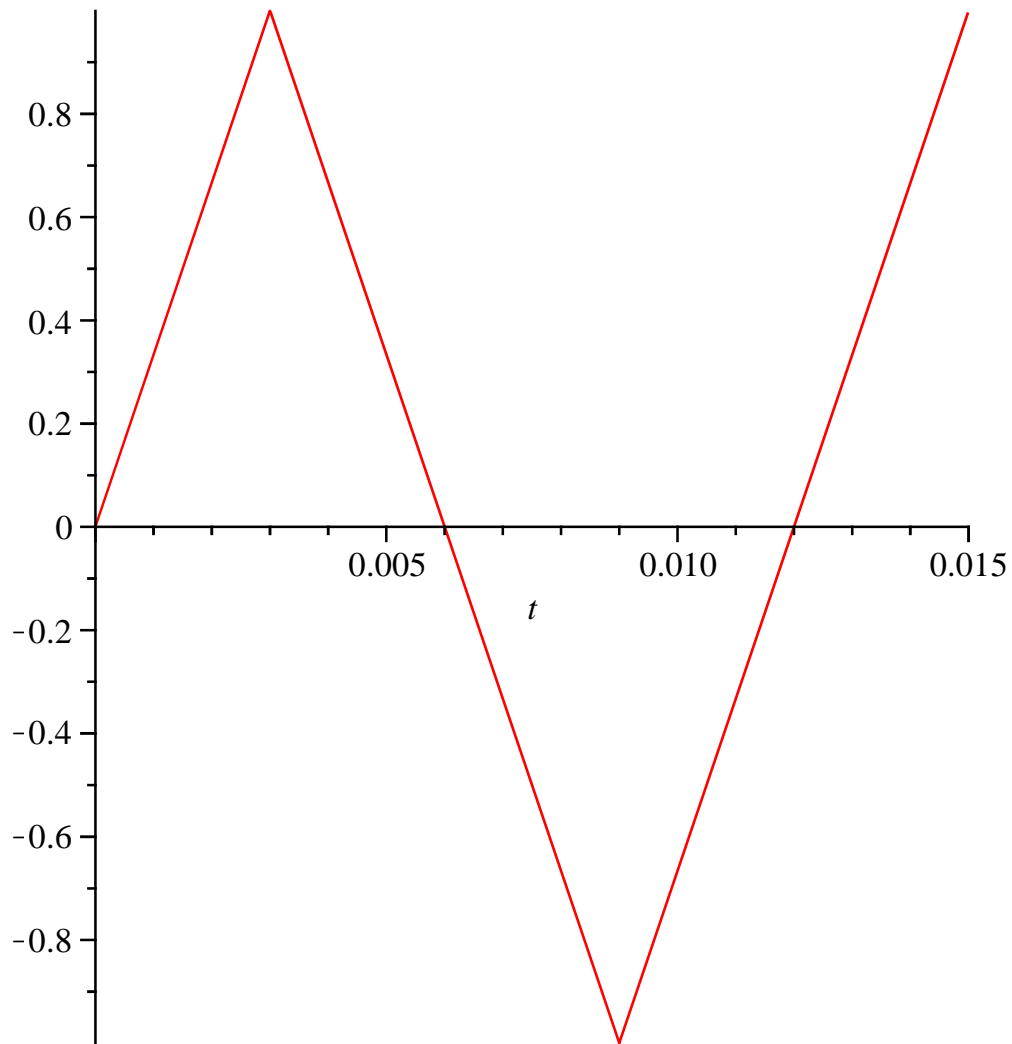
$$vin := \frac{v0 \cdot t}{\left(\frac{T}{4}\right)} \left( \text{Heaviside}(t) - \text{Heaviside}\left(t - \frac{T}{4}\right) \right) + \left( -\frac{2 \cdot v0}{\left(\frac{T}{2}\right)} \left(t - \frac{T}{4}\right) + v0 \right) \cdot \left( \text{Heaviside}\left(t - \frac{T}{4}\right) - \text{Heaviside}\left(t - \frac{3 \cdot T}{4}\right) \right) + \left( \frac{2 \cdot v0}{\left(\frac{T}{2}\right)} \cdot \left(t - \frac{3 \cdot T}{4}\right) - v0 \right) \cdot \left( \text{Heaviside}\left(t - \frac{3 \cdot T}{4}\right) - \text{Heaviside}\left(t - \frac{5 \cdot T}{4}\right) \right);$$

$$333.3333333 t \left( \text{Heaviside}(t) - \text{Heaviside}(t - 0.003000000000) \right) + (-333.3333333 t + 2.000000000) \left( \text{Heaviside}(t - 0.003000000000) - \text{Heaviside}(t - 0.009000000000) \right) + (333.3333333 t - 4.000000000) \left( \text{Heaviside}(t - 0.009000000000) - \text{Heaviside}(t - 0.01500000000) \right)$$

(2)

Check the input is right

$plot(vin, t = 0 .. 0.015);$

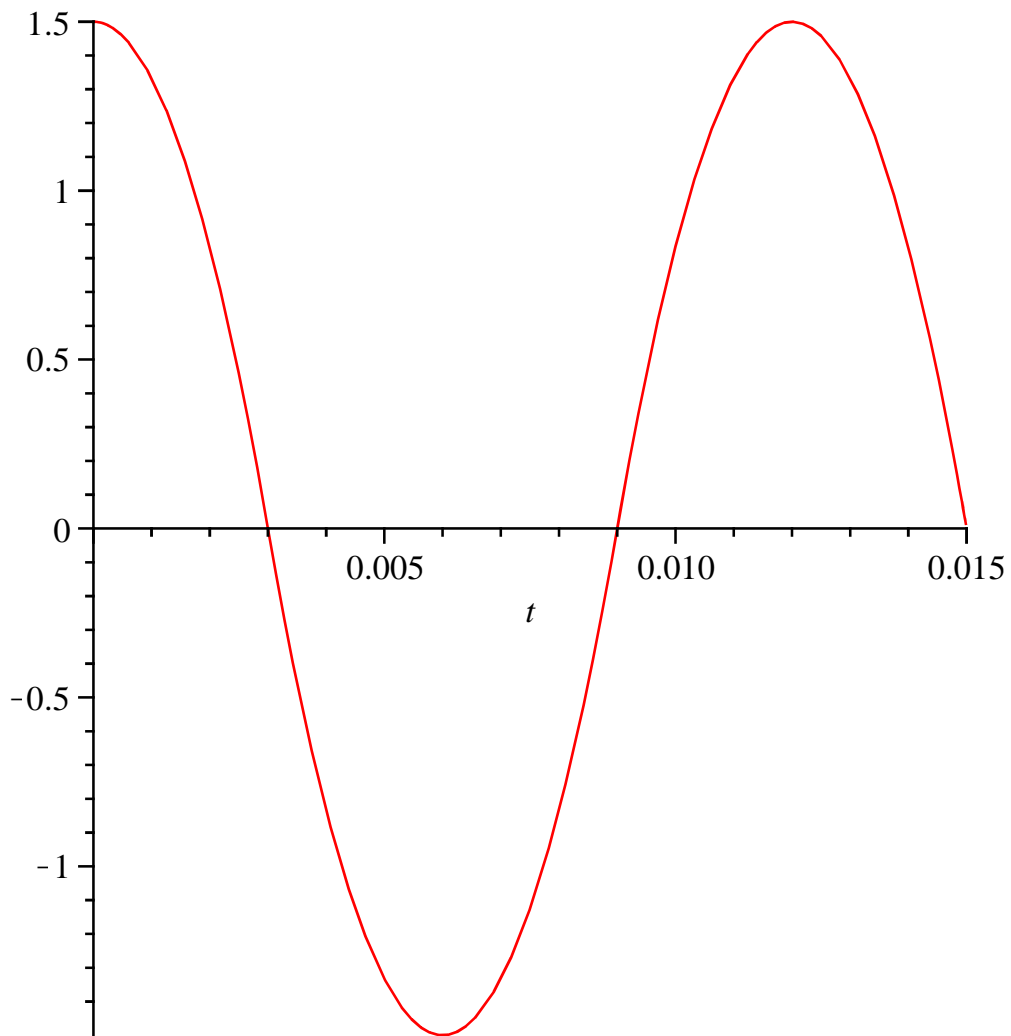


Integrate making sure the average is zero (capacitors average DC)

$$v_{out} := -\frac{1}{r \cdot c} \cdot \text{int}(v_{in}, t) + 1.5;$$

$$\begin{aligned}
 & -1.6666666666 \cdot 10^5 \text{Heaviside}(t) t^2 + 3.3333333333 \cdot 10^5 \text{Heaviside}(t - 0.003000000000) t^2 \\
 & + 3.0000000000 \text{Heaviside}(t - 0.003000000000) - 3.3333333333 \cdot 10^5 \text{Heaviside}(t \\
 & - 0.009000000000) t^2 - 27.00000000 \text{Heaviside}(t - 0.009000000000) \\
 & - 2000.000000 t \text{Heaviside}(t - 0.003000000000) + 6000.000000 t \text{Heaviside}(t \\
 & - 0.009000000000) + 1.6666666666 \cdot 10^5 \text{Heaviside}(t - 0.015000000000) t^2 \\
 & + 22.50000000 \text{Heaviside}(t - 0.015000000000) - 4000.000000 t \text{Heaviside}(t \\
 & - 0.015000000000) + 1.5
 \end{aligned} \tag{3}$$

plot(vout, t = 0 .. 0.015);



Overlay with a sine function for fun to see how good the parabolic approximation is

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w :=  $\frac{\text{evalf}(2 \cdot \text{Pi})}{T}$ ; vtest := 1.5 \cdot \cos(w \cdot t);
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523.5987757

1.5 cos(523.5987757 t)

(4)

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plot( {vout, vtest}, t = 0 .. 0.015);
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