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## Impulse response

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So far circuits have been driven by a DC source, an AC source and an exponential source. If we can find the current of a circuit generated by a Dirac delta function or impulse voltage source  $\delta$ , then the convolution integral can be used to find the current to any given voltage source!

### Example Impulse Response

The current is found by taking the derivative of the current found due to a DC voltage source! Say the goal is to find the  $\delta$  current of a series LR circuit ... so that in the future the convolution integral can be used to find the current given any arbitrary source.

Choose a DC source of 1 volt (the real  $V_s$  then can scale off this). The particular homogeneous solution (steady state) is 0. The homogeneous solution to the non-homogeneous equation has the form:

Assume the current initially in the inductor is zero. The initial voltage is going to be 1 and is going to be across the inductor (since no current is flowing):

$$v(t) = L \frac{di(t)}{dt}; v(0) = 1 = L * \left(-\frac{AR}{L}\right);$$

If the current in the inductor is initially zero, then:

Which implies that:

So the response to a DC voltage source turning on at  $t=0$  to one volt (called the unit response  $\mu$ ) is:

$$i_{\mu}(t) = \frac{1}{R} \left(1 - e^{-\frac{t}{\frac{L}{R}}}\right)$$

Taking the derivative of this, get the impulse ( $\delta$ ) current is:

Now the current due to any arbitrary  $V_s(t)$  can be found using the convolution integral:

Don't think  $i_{\delta}$  as current. It is really  $\frac{d \text{ current}}{dt \text{ 1volt}} \cdot V_s(\tau)$  turns into a multiplier.

### LRC Example

Find the time domain expression for  $i_o$  given that  $I_s = \cos(t + \pi/2)\mu(t)$  amp.

Earlier the step response for this problem was found:

The impulse response is going to be the derivative of this:

$$i_o(t) = \int_0^t i_{os}(t - \tau) I_s(\tau) d\tau + C_1$$

The Mupad code to solve the integral (substituting x for  $\tau$ ) is:

```
f := exp(-(t-x)) *sin(t-x) *(1 + cos(x));<br>S := int(f,x = 0..t)
```

## Finding the integration constant

This implies: