indoor temperature prediction - using real datas to fit a RC analog model

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I. ANOTHER WAY TO DISCRETIZE THE PROBLEM

$$T_p(t) = \begin{vmatrix} T_i(t) \\ T_s(t) \end{vmatrix}$$

The solution of $\frac{dT_p(t)}{dt} = A(p)T_p(t) + B(p)U(t)$
can be expressed as :

$$T_p(t) = e^{A(p)t}T_0 + \int_0^t e^{A(p)(t-s)}B(p)U(s)ds$$

We can write :
$T_p(t+\delta t) = e^{A(p)\delta t}e^{A(p)t}T_0 + \int_0^t e^{A(p)(t+\delta t-s)}B(p)U(s)ds + \int_t^{t+\delta t} e^{A(p)(t+\delta t-s)}B(p)U(s)ds$
which leads to :

$$T_p(t+\delta t) = e^{A(p)\delta t}T_p(t) + \int_t^{t+\delta t} e^{A(p)(t+\delta t-s)}B(p)U(s)ds$$

or :

$$T_p(t+\delta t) = e^{A(p)\delta t}T_p(t) + e^{A(p)\delta t}\int_t^{t+\delta t} e^{A(p)(t-s)}B(p)U(s)ds$$

With $T = s - t$, we have :

$$T_p(t+\delta t) = e^{A(p)\delta t}T_p(t) + e^{A(p)\delta t}\int_0^{\delta t} e^{-A(p)T}B(p)U(T+t)dT$$

Assuming δt to be very small, we can estimate that $U(T+t)$ to be constant and equal to $U(t)$
The primitive of exp^{-at} being $c - a^{-1}exp^{-at}$, we can write :

$$T_p(t+\delta t) = e^{A(p)\delta t}T_p(t) + e^{A(p)\delta t}A(p)^{-1}(-e^{-A(p)\delta t} + I)B(p)U(t)$$

or :

$$T_p(t+\delta t) = e^{A(p)\delta t}T_p(t) + A(p)^{-1}(e^{A(p)\delta t} - I)B(p)U(t)$$