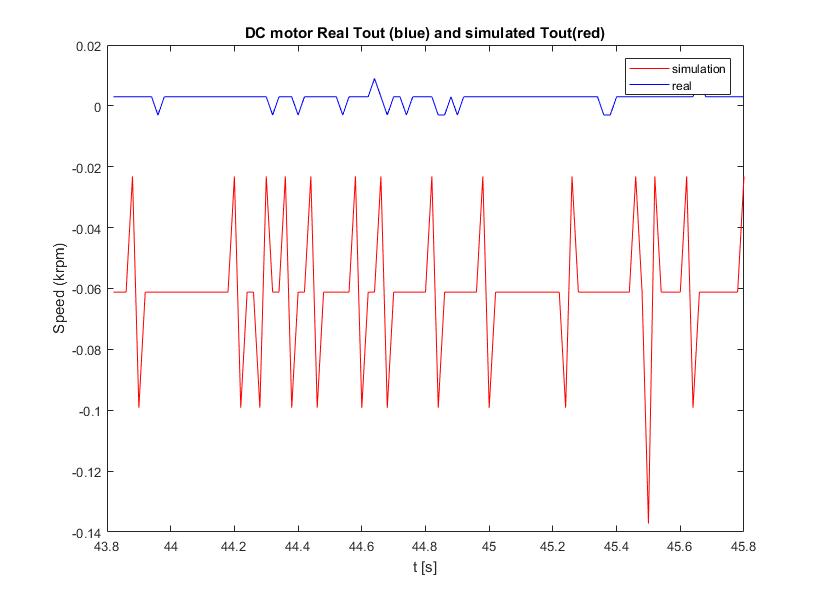
Ex1. **Parameter estimation of a DC motor with least squares (LS) method**

The dataset were split into two parts. The first part was used to fitted the LS model, and the last 100 observations were used for validation test. The plot of the validation output was shown as below. Very large fluctuation was found compared with the real data.



Ex2.  **Parameter estimation of an air heater using the grid optimization method:**

The objective function for grid search, where the variables Tout\_f, U\_f, dTheatdt\_f stand for variables for parameters estimation. The last 100 observations were taken out from the original data for the validation.

f=(Tout\_f(i) - (Tenv+Kh\*U\_f(i)\*(t\_f(i)-theta\_d)-theta\_t\*dTheatdt\_f(i)))^2

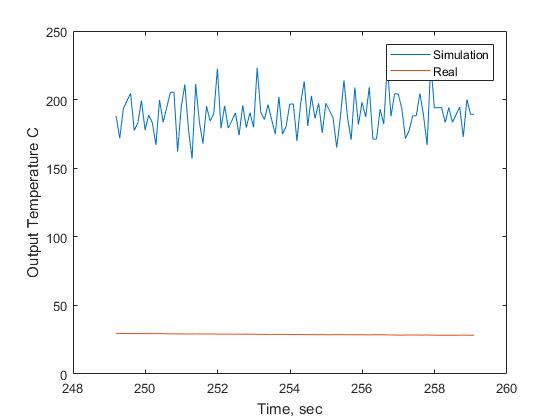
The results of simulation output are:

f\_min = 48497e-11;

Tenv\_opt=14.4737; Kh\_opt=0.7895; theta\_t\_opt=28.4211; theta\_d\_opt=3.6842.

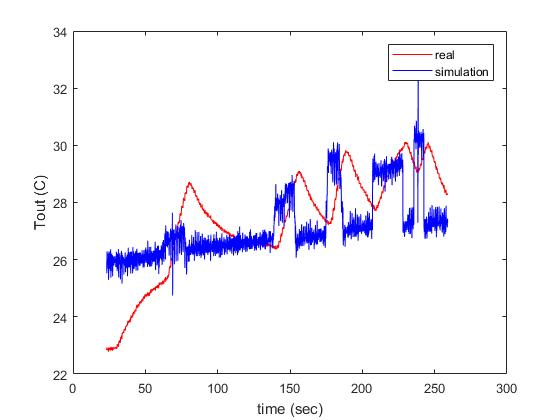
f\_min is very close to zero, which means the parameters estimation is fine.

A simulation based the estimated parameters was carried out as the figure below. The result is not satisfactory. It is mainly because the interval for searching cannot be a high density due to computation time limit.



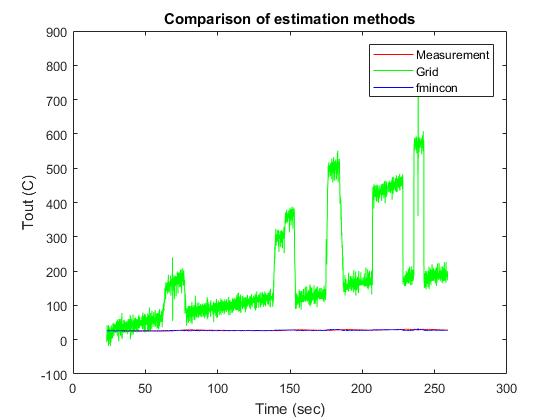
Ex3.  **Parameter estimation of the air heater using the nonlinear least squares (NLS) method**

See the Matlab script. A simulation plot is shown as below.



EX4. **Comparison of estimation results**

The measured Tout, grit optimization simulated Tout, and fmincon simulated Tout are plotted in the same figure as below. The estimation performs much better than that of grit search. However, if the grid search interval can be shorter, the grid optimization can be also improved. But grid optimization need a better computational power and more time for computation.



EX5. **Subspace identification of the air heater**

The discrete state space model were obtained as below:

Tout(t+Ts)= A\*x(t) + B\*u(t) + B\*u(t) + K\*e(t)

y(t) = C\*x(t) + D\*u(t) + e(t)

where: A=0.9996, B=2.427e-5, C=416.3, D=0

The simulation is shown as below:

