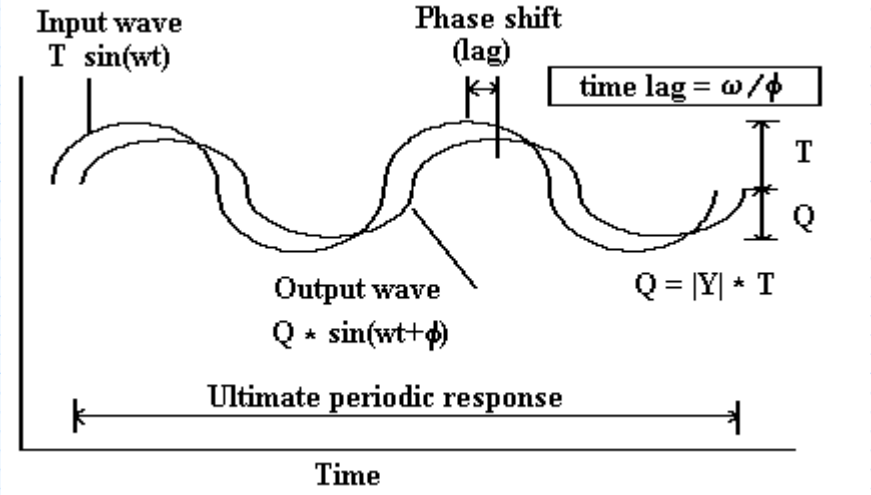
CHAPTER 4 PERIODIC HEAT FLOW IN MULTILAYERED WALLS

4.1 Principles of Steady Periodic Analysis of Wall Heat Flow

Frequency domain analysis techniques with complex variables are usually employed for steady periodic analysis of multilayered walls. They provide a convenient means for periodic analysis, in which the main parameters of interest are the magnitude and phase angle of room temperatures and heat flows.

Significant insight into wall dynamic thermal behavior may be obtained by studying its admittance transfer functions (magnitude and phase angle) as a function of frequency, thermal properties and geometry.

The sketch below shows how wall response to weather inputs (e.g. T·sin(wt)) may be obtained for one harmonic and the time lag between the input and output waves. For inputs with more than one harmonic, the total response is obtained by superposition of the response harmonics.



Y = admittance transfer function with magnitude |Y| and phase angle ϕ

Outside temperature and solar radiation are modeled by discrete Fourier series as described in **Section 4.3**. Note that solar radiation absorbed by an exterior surface can be combined with outside temperature To to form an equivalent temperature known as the sol-air temperature Teo. Teo is defined by writing an energy balance at the wall exterior surface (ignoring long wave radiant exchange with the sky):

$\alpha_s \cdot S + h_o \cdot (To - Ts) = q_{in}$ heat flow into wall due to solar flux S and To

Write the energy balance in the form:

$h_o \cdot (Teo - Ts) = q_{in}$

Therefore

$$Teo = \alpha_s \cdot \frac{S}{ho} + To$$

Example:

$To := -1\ \Delta°C$ outside temperature

$S := 200\ \frac{W}{m^2}$ mean solar radiation incident on wall

$\alpha_s := 0.9$ solar absorptance

$h_o := 15\ \frac{W}{m^2 \cdot \Delta°C}$ exterior film coefficient

Sol-air temperature:

$$Teo := \frac{\alpha_s \cdot S}{h_o} + To = 11\ \Delta°C$$

Sol-air temperature is given for different surfaces in the *ASHRAE Handbook of Fundamentals*. It can be calculated here based on the given ratio of solar absorptance to film coefficient.

References

ASHRAE. 1989. *ASHRAE Handbook of Fundamentals*. Atlanta, GA.