**Step Test January 21, 2021**

Summary: A step test was done on a ~32 F day with the sunshine room pre-cooled by keeping the door closed, heat off, and woodstove fire mostly stoked. The fire was fully stoked, waited 15 minutes, then went full blast on the ECMF-15 fan. There was some non-minimum phase behavior caused by fan draft that should only act like a beneficial kicker during use. There was duct heat soak observed. And the room time constant was observed.

Setup:

1. Home heating system off. Nominal desired thermostat setting usually 68 F.
2. Begin by isolating room for ~4 hours. OAT ~32 F. Keep fire stoked in meantime.
3. Use infrared thermometer to monitor duct heat soak response. Remove the grill from room vent and shoot the plastic duct hose visible straight in the hole.
4. Use system sensors: plenum probe about 8 inches into intake supply to fan and Honeywell HIH mounted on the PLC.
5. PLC prototype set onto the sunshine room shelf at knee height in the room, about where it will be on installation. Use USB Serial to monitor the system sensors for test.
6. Fan speed directly controlled by POT jumpered to the ECMF 0-10 volt control inputs.

Conclusion:

1. There is sufficient data to create a simple first order model of the system
2. There is control authority with enough temperature potential to close loop on room air to a reference of thermostat – 3 F when potential plenum is greater than 12 F above thermostat setting.
3. Duct heat soak time constants
   1. 30 sec short term
   2. 360 sec long term
4. Room time constant is 4500 sec.
5. There is non-minimum phase response due to room air movement that is on the order of 1500 seconds. The practical effect if ignored will be to introduce a small beneficial control kicker.

Discussion: It was disappointing that there was so much temperature drop through the ductworks. It leaves little margin for controlling room temperature but there is some. More insulation would help and there is a loop of duct near the fan that could be removed. Time constants are so slow that it would be easy for user to manage comfort. But the primary objective is to remove all burden from the user, an a-priori assumption. In the end, closing the loop will

* Turn the fan on at appropriate conditions
* Allow reducing fan action to reasonable levels for better equipment management

I observed a lot of temperature stratification in the room even when the fan is blowing. So fan size also contributes to controllability, in addition to duct loss and wood stove output. Putting the room sensor at knee height still directly measures user comfort and even if controllability is reduced by putting it there we can accept the consequences: fan running at max speed. Not really an issue since supply muffler works extremely well and fan made to run continuous duty using only 40 W.