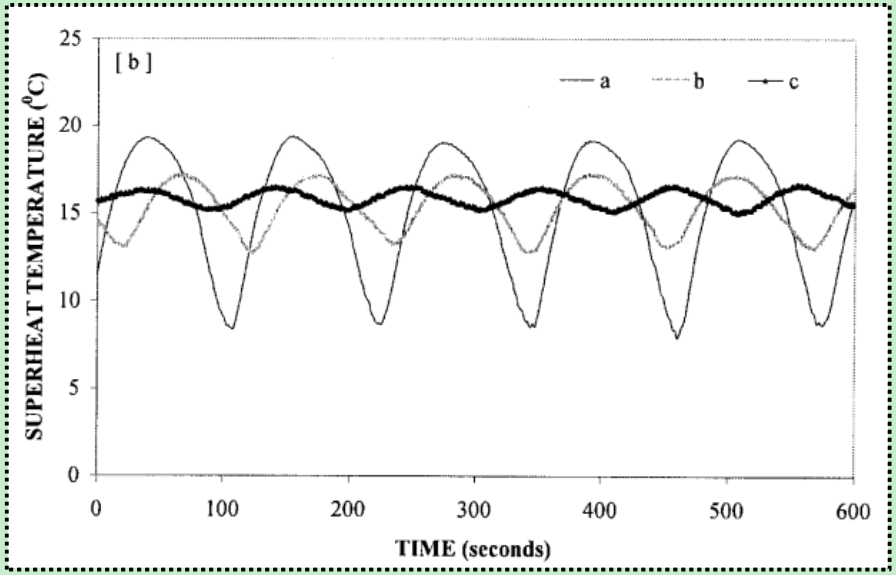
A modeling study on the operational stability of a variable speed (VS) direct expansion (DX) air conditioning (A/C) system

Yu Dong XIA, Shi Ming DENG*

Department of Building Services Engineering,
The Hong Kong Polytechnic University, Hong Kong SAR, China

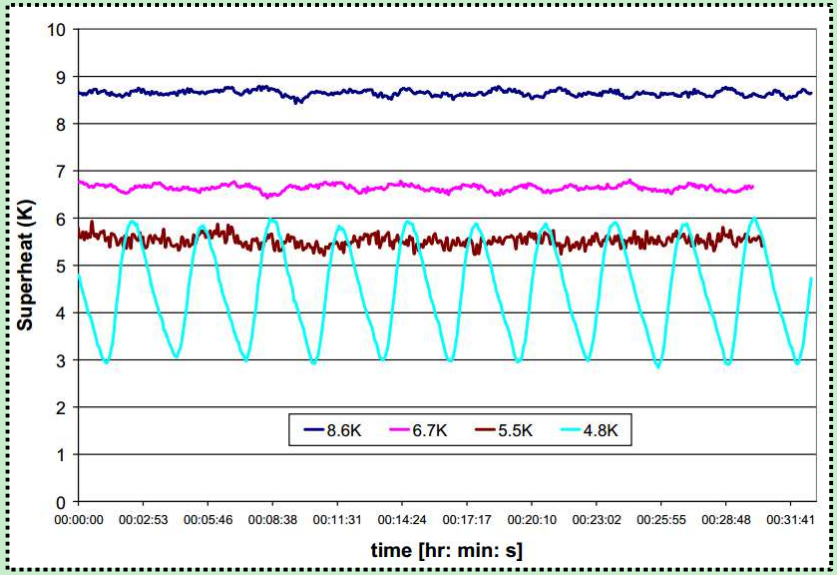
Operational instability in refrigeration systems

Hunting



Mithraratne. P (2002)

TEV controlled



Fallahsohi H. (2010)

EEV controlled

Operational instability in refrigeration systems

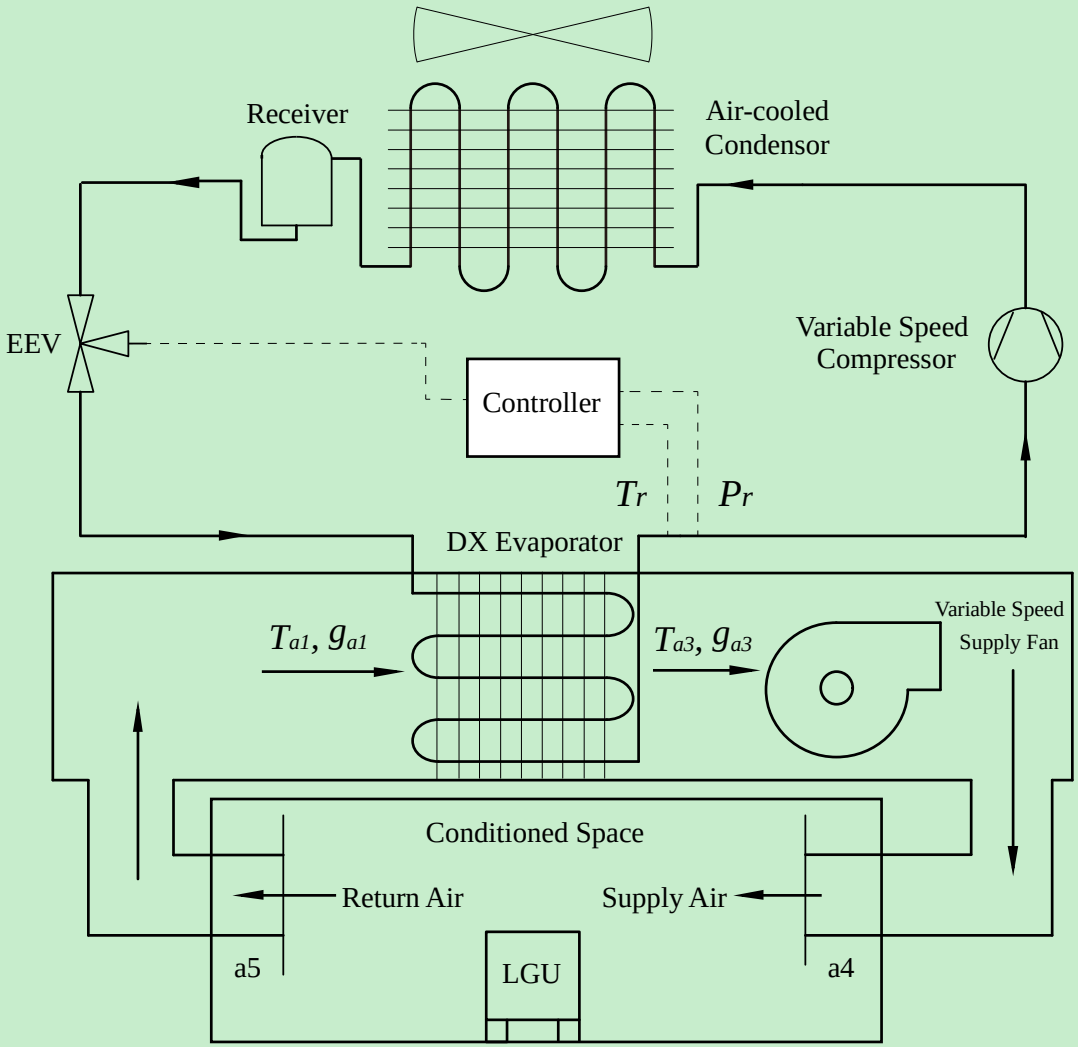
Hunting

- the control characteristics of an expansion valve
- the inherent characteristics of an evaporator

Research gap

- Less studies on the operational stability for EEV-controlled systems.
- No previously studies on the influence of the air side operating characteristics on the operational stability

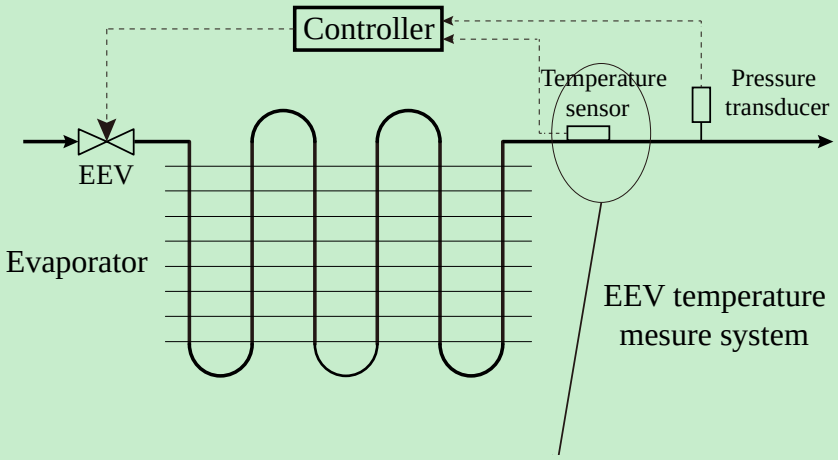
Modelled VS DX A/C system



Refrigerant side

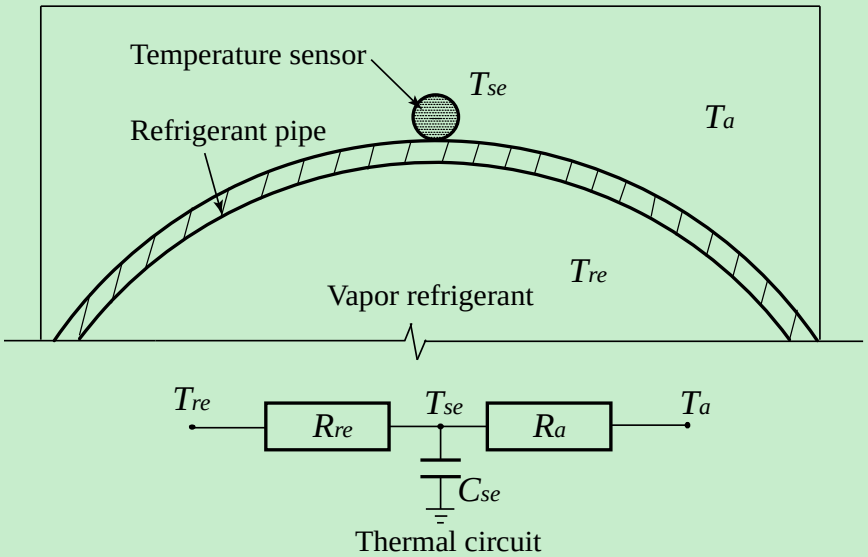
Air side

Further model development for the EEV sub-model



$$\frac{dT_{se}(t)}{dt} + \frac{1}{\tau_{se}} T_{se}(t) = \frac{1}{\tau_{se}} T_{re}(t)$$

$$\tau_{se} = R_{re}(\rho C_p V)_{se}$$



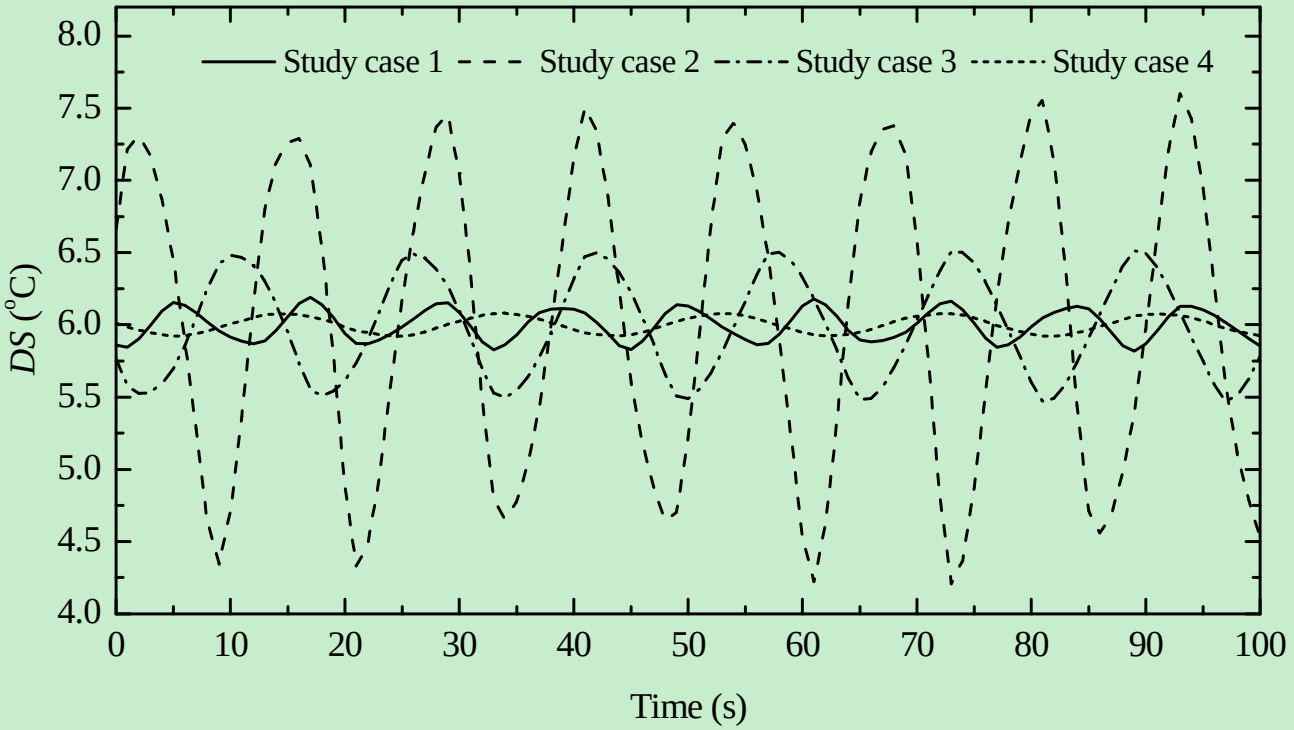
Heat transfer

The Influences of Dynamic Characteristics of EEV's Temperature Sensor on the System Operational Stability

Four cases of different unit thermal contact resistances

Study group	Study case	Thermal contact resistance R_2' (m^2 K kW^{-1})	Compressor speed (rpm)	Supply fan speed (rpm)
I	1	0.050	5544	2448
	2	0.075		
	3	0.125		
	4	0.200		

The Influences of Dynamic Characteristics of EEV's Temperature Sensor on the System Operational Stability



The simulated *DS* for study group I

thermal contact resistances

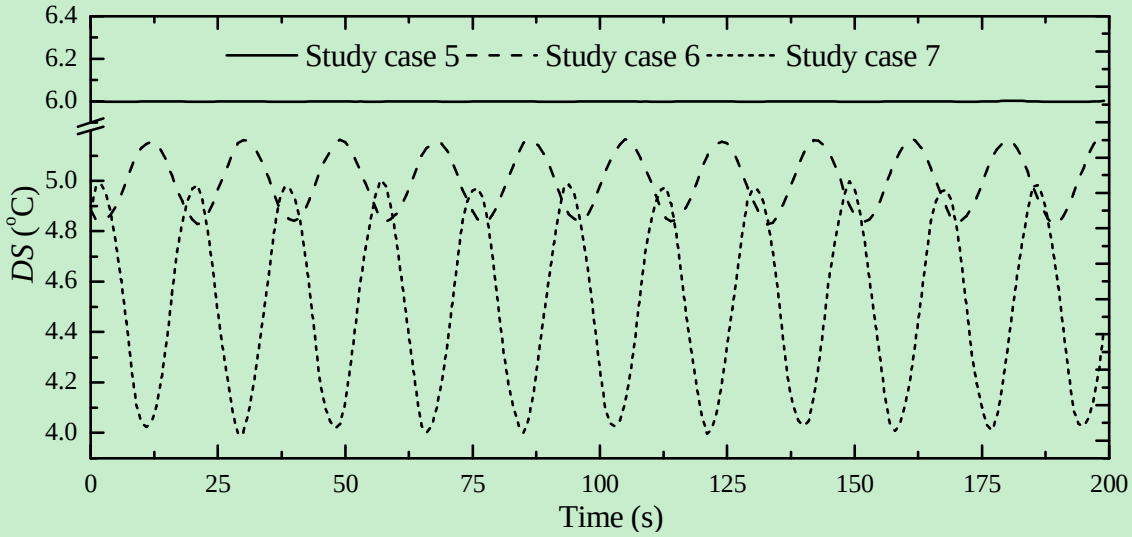
↕

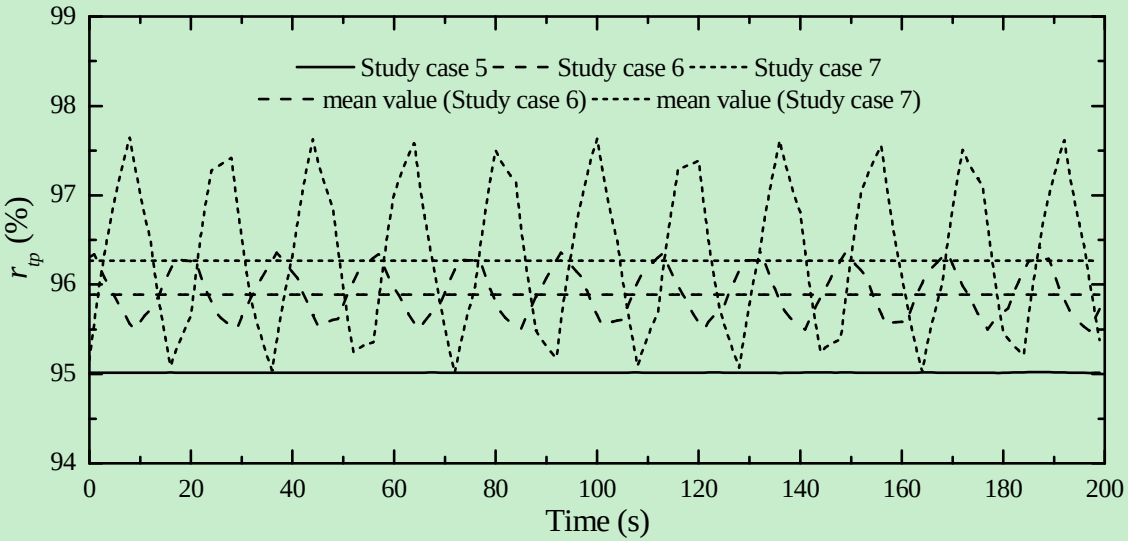
Hunting

The Influences of the Variable Speed Operation on the System Operational Stability

Three study groups of different variable speed operating parameters

Study group	Study case	Compressor speed (rpm)	Supply fan speed (rpm)	DS setting (°C)
III	5	4488	2160	6
	6			5
	7			4.5
IV	8	4488	2160	6
	9	5016		
	10	6072		
V	11	4488	2160	6
	12		2064	
	13		1968	





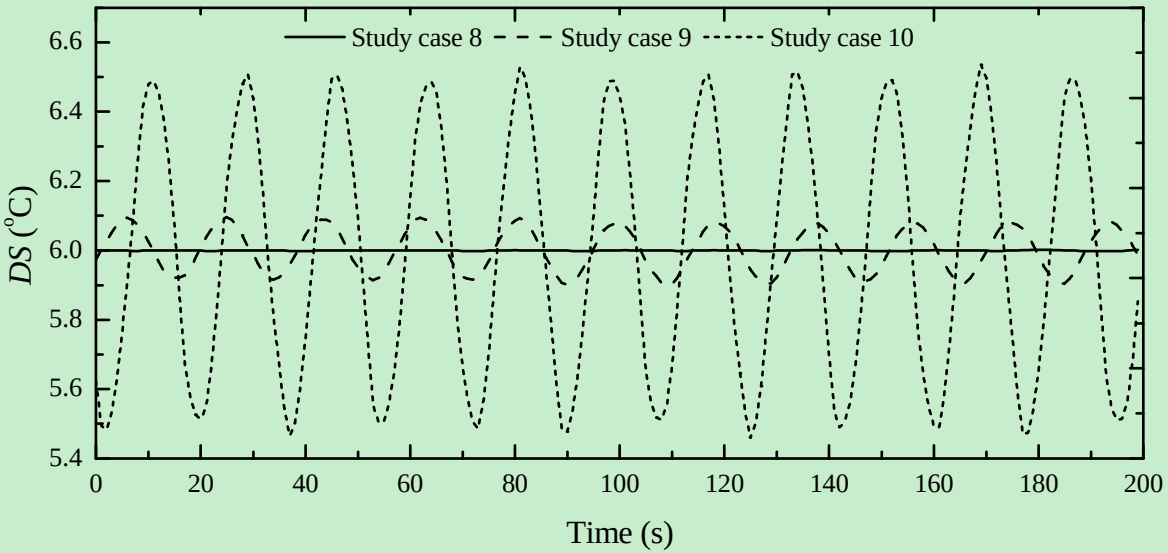
DS setting

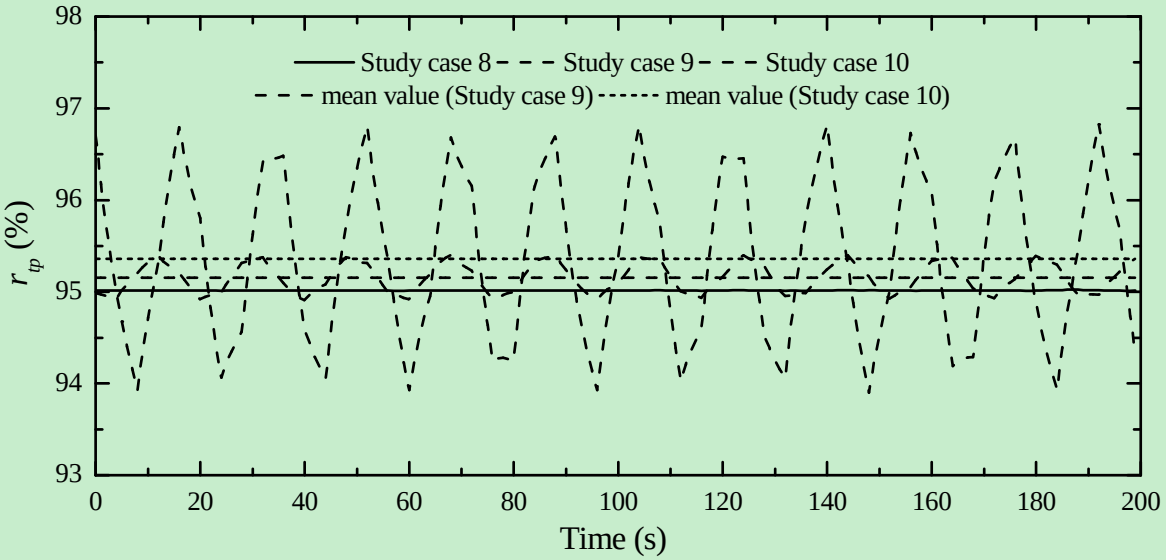
↕

mixture-vapor transition point

↕

Hunting





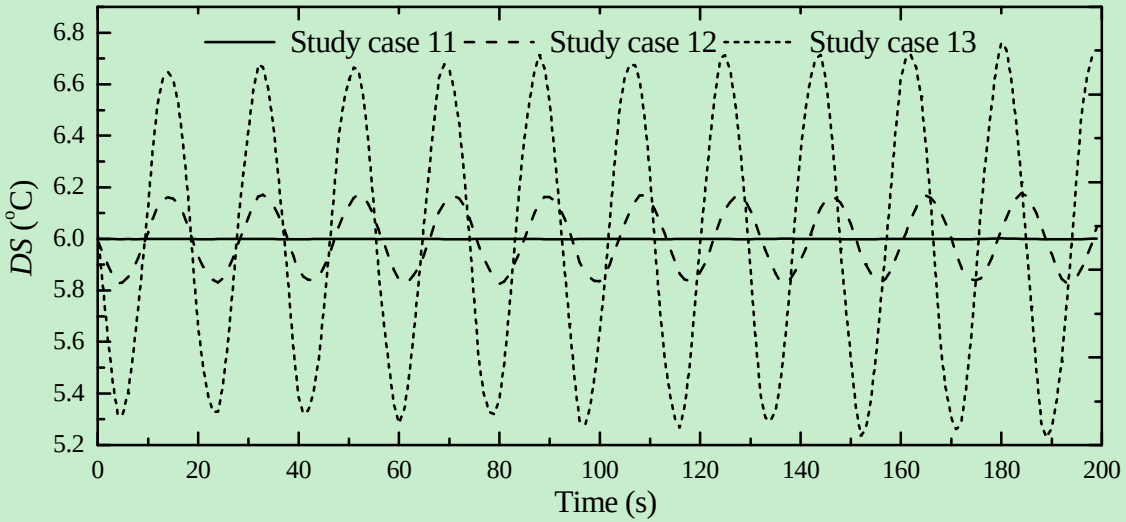
Compressor speed

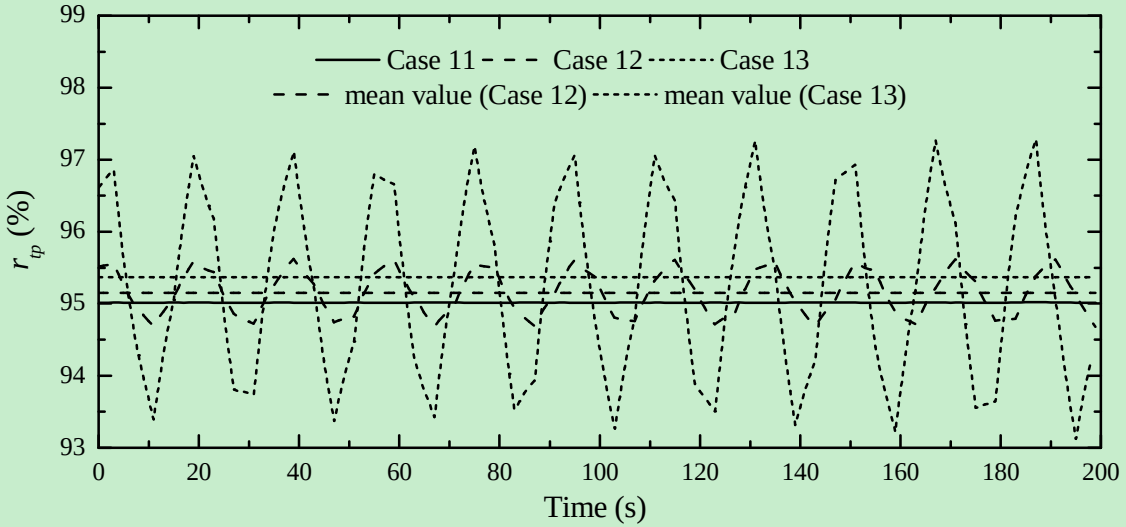
↕

mixture-vapor transition point

↕

Hunting





Fan speed

↕

mixture-vapor transition point

↕

Hunting

Conclusions

- **Slowing down the rate of DS signal transfer by increasing the thermal resistance between the sensor and refrigerant inside the pipeline may help mitigate the instability.**

- **A higher compressor speed or a lower supply fan speed would cause the movement of mixture-vapor point towards evaporator exit, leading to likely system hunting.**

Thank You

Q&A