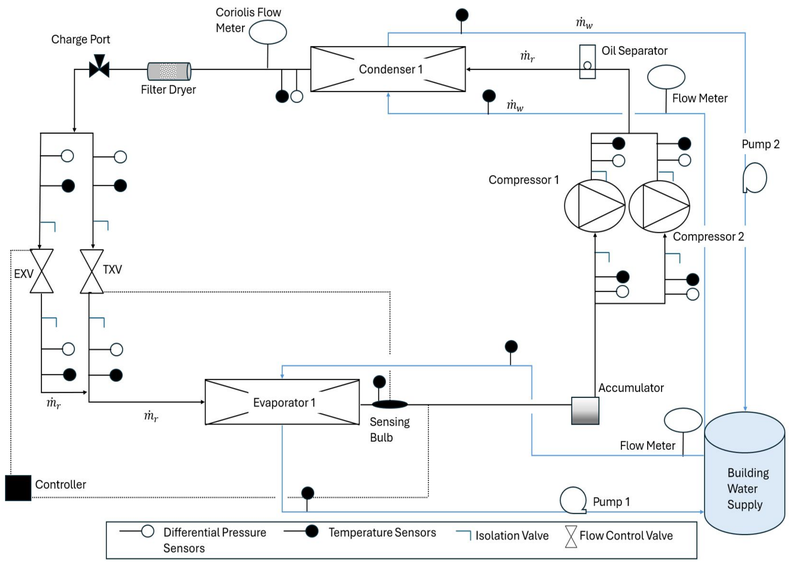
Air Conditioning Expansion Valve Test System

MECHANICAL ENGINEERING
UNIVERSITY OF MINNESOTA

Martina Ladich, Mike Le, Akram Zemzemi , Aiden Wang, Ethan Janssen

DAIKIN

SYSTEM OVERVIEW



Bench Architecture

- Dual-valve branches **(EXV + TXV)** for comparative testing
- Wide capacity envelope: 0.8–15 tons
- Mass flow range:

TXV (20–2000 lb/hr) **EXV (80–1700 lb/hr)**

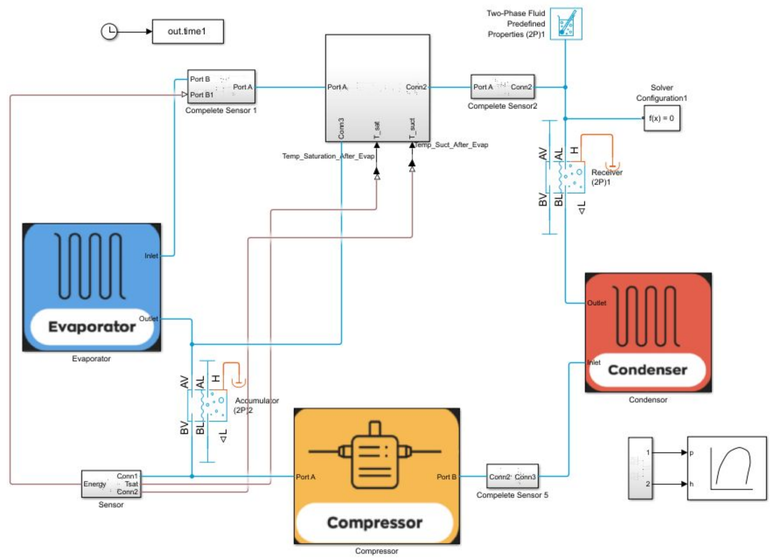
- Repeatable valve characterization with R-32
- Compact 10×8×5 ft system footprint

Purpose

Develop a system and predictive model to **characterize electronic expansion valve and thermostatic expansion valve behavior** across a wide operating range. Reliable valve data enables **performance optimization** for Daikin HVAC systems.

MODEL & VALIDATION

Model Architecture



Digital Twin Features

- Two-phase heat exchangers (TL–2P blocks)
- Compressor map–based flow model
- EXV PI controller for superheat control
- TXV mechanical model for comparison
- Fully parameterized R-32 refrigerant loop

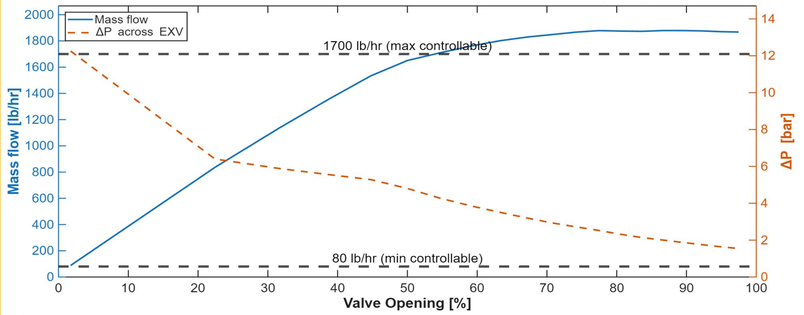
Validation Framework

Phase 1 **Component Validation** → Phase 2 **Cycle Validation** → Phase 3 **Control Validation** → Phase 4 **Envelope & Stability**

Validation ensures accurate compressor, coil, and valve behavior so the digital twin matches the physical test bench across all operating conditions.

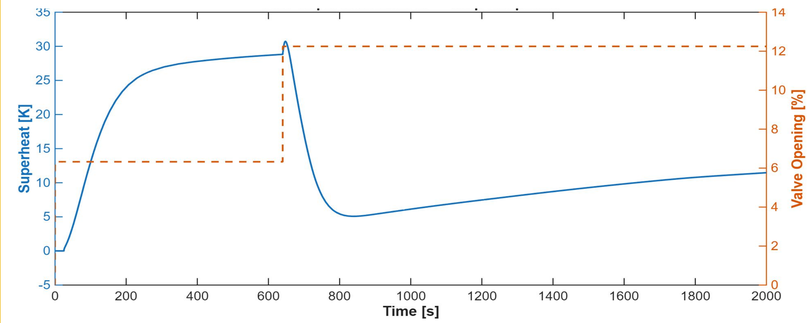
KEY RESULTS

1. EXV Valve Map — Mass Flow vs Opening



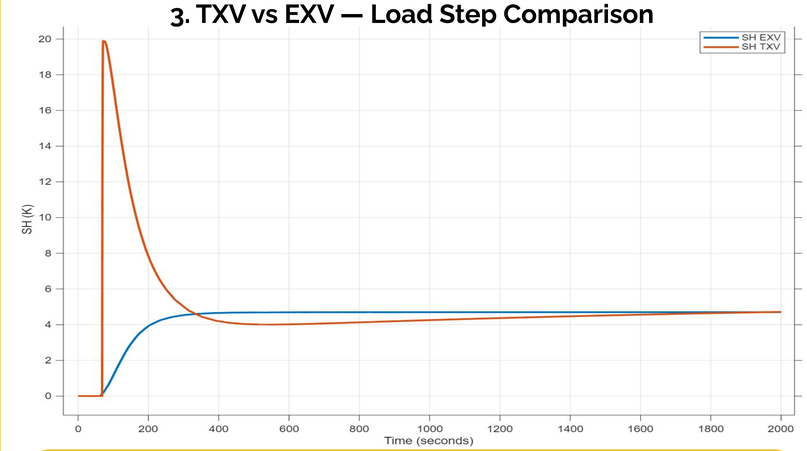
- Mass flow increases predictably with opening
- ΔP remains stable across the test range
- Bench meets EXV test envelope (80–1700 lb/hr)

2. EXV Superheat Control — Step Response



- Predictable SH drop, no instability
- Smooth settling to new steady state
- SH stays > 0 K (no floodback)

3. TXV vs EXV — Load Step Comparison



- TXV shows lag, shows overshoot.
- EXV maintains stable superheat during disturbances
- Demonstrates advantage of electronic control under load

FUTURE DEVELOPMENT

- **Multi-refrigerant support for broader valve testing**
- **EXV model upgrade using manufacturer flow data**
- **Automated DAQ-driven test cycles (hands-off operation)**
- **Real-time sync of simulation and physical bench data**
- **Leak detection + auto-shutdown for hardware protection**

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Resources:

GitHub Repository

Full Report