

Air Conditioner and Stall Solutions Test Results


DOE Workshop
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Air Conditioner Testing

- BPA, EPRI, & SCE tested >25 A/C units
 - **Manufacturers:** various
 - **Size:** 2.5 to 5 tons
 - **Compressor type:** reciprocating & scroll
 - **Refrigerant type:** R-22 & R-410A
 - **SEER:** 10 thru 13
 - **System type:** Split & Package
 - **Vintage:** Mostly new & one 10 years old
- Test parameters
 - **Outdoor temperature:** 80°F, 100°F & 115°F
 - **Indoor temperature:** 75 °F

Air Conditioner Testing

■ Voltage Tests

- **Square UV sag:** 30 sec. 

- **Ramp-up UV sag:** 30 sec. 

- **UV transients:** 3, 6, 9, 12 cycle 

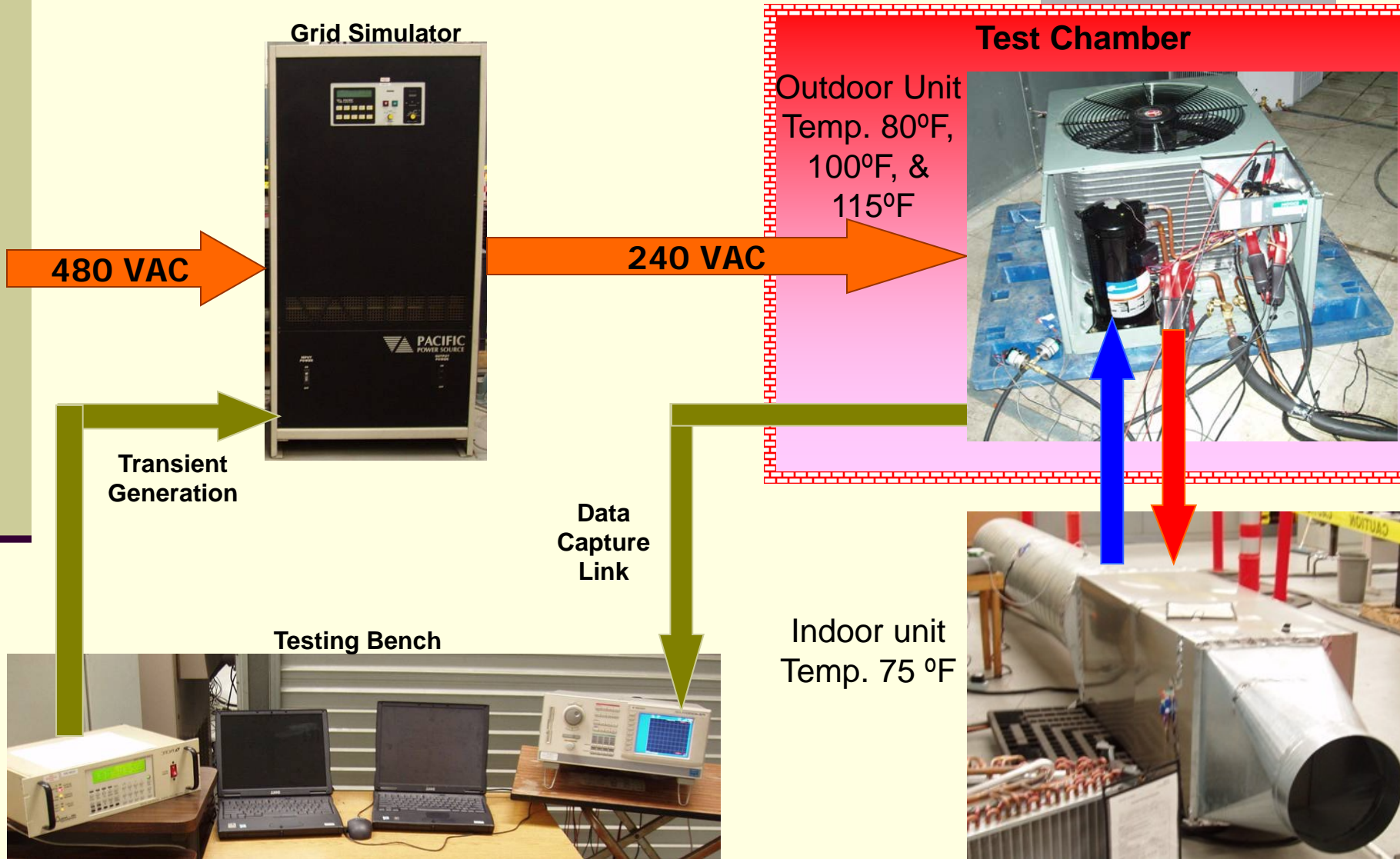
- **Voltage oscillations:** 0.1 to 0.5 Hz

■ Frequency Tests

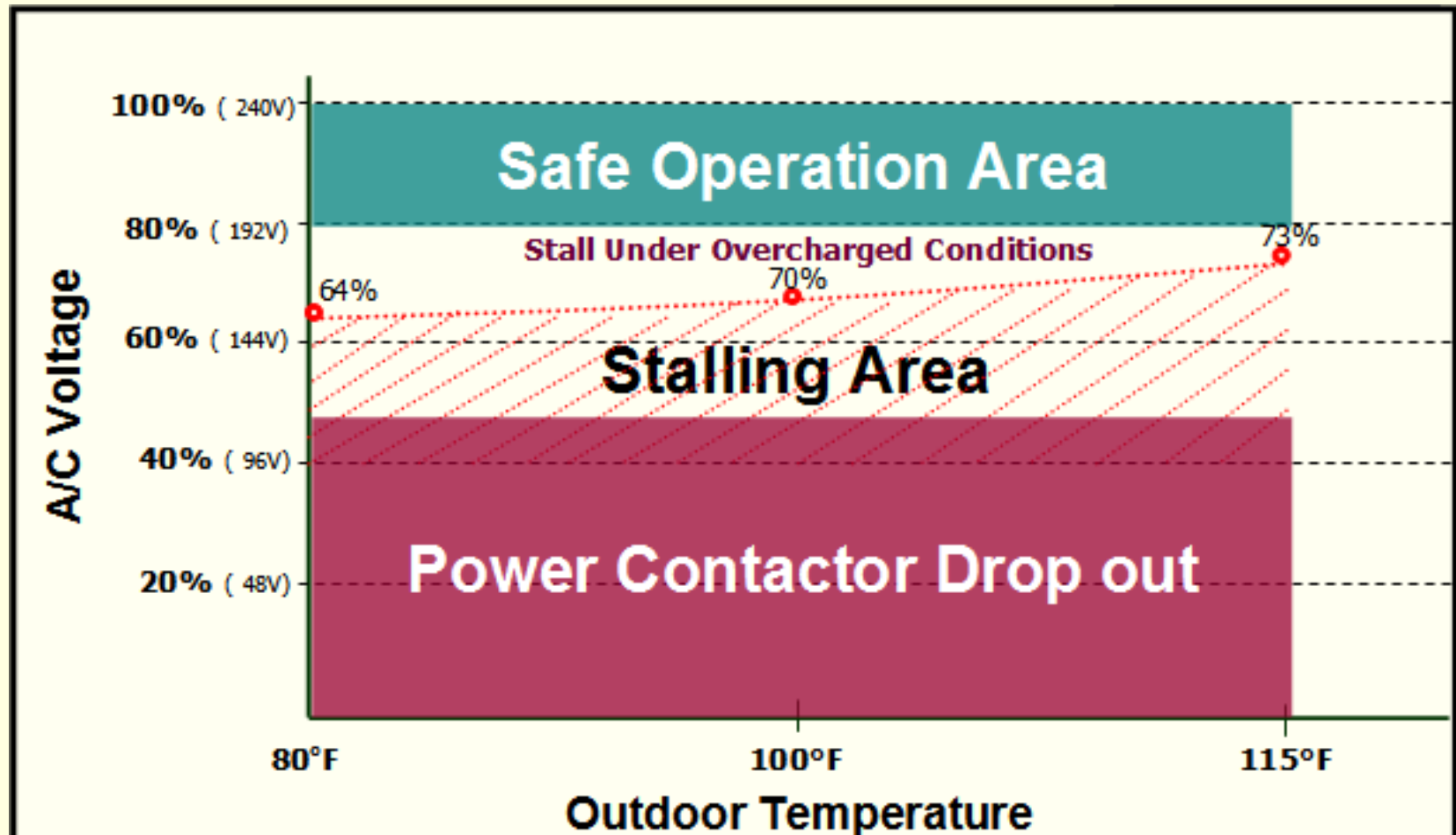
- **Deviation:** 0.1 Hz steps

- **Oscillations:** 0.1 to 0.5 Hz

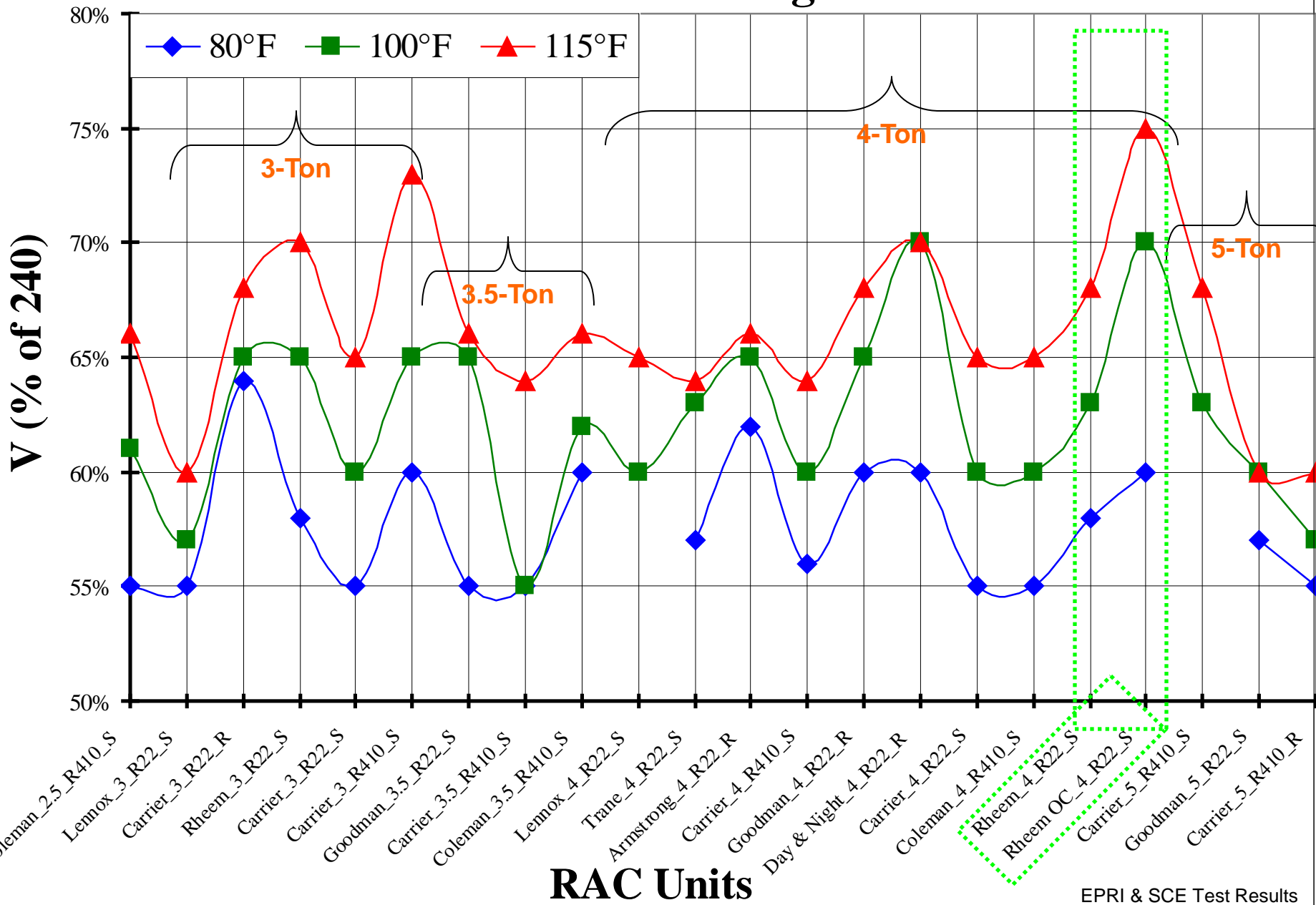
Air Conditioner Test Layout



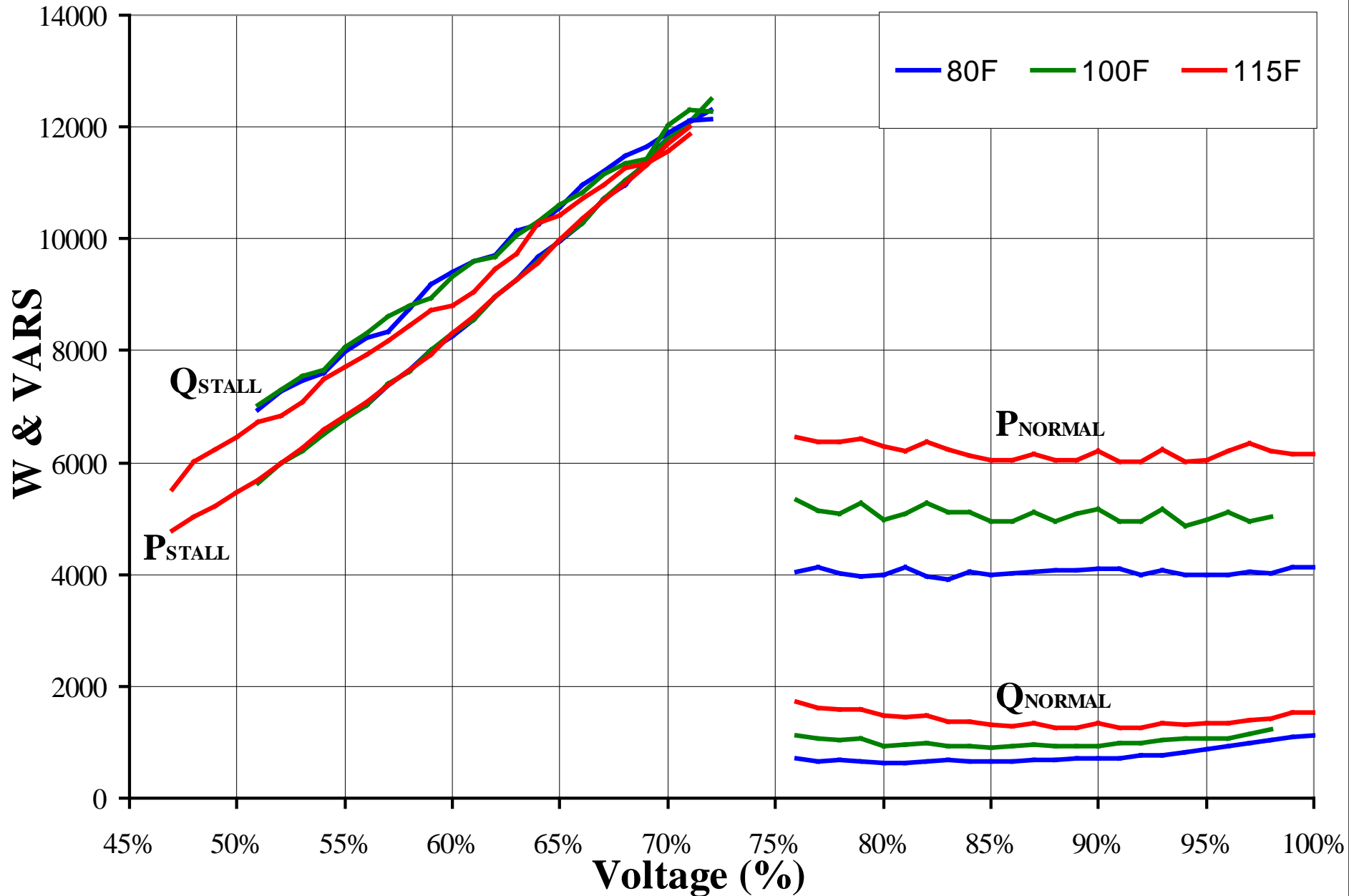
When Do A/C Units Stall?



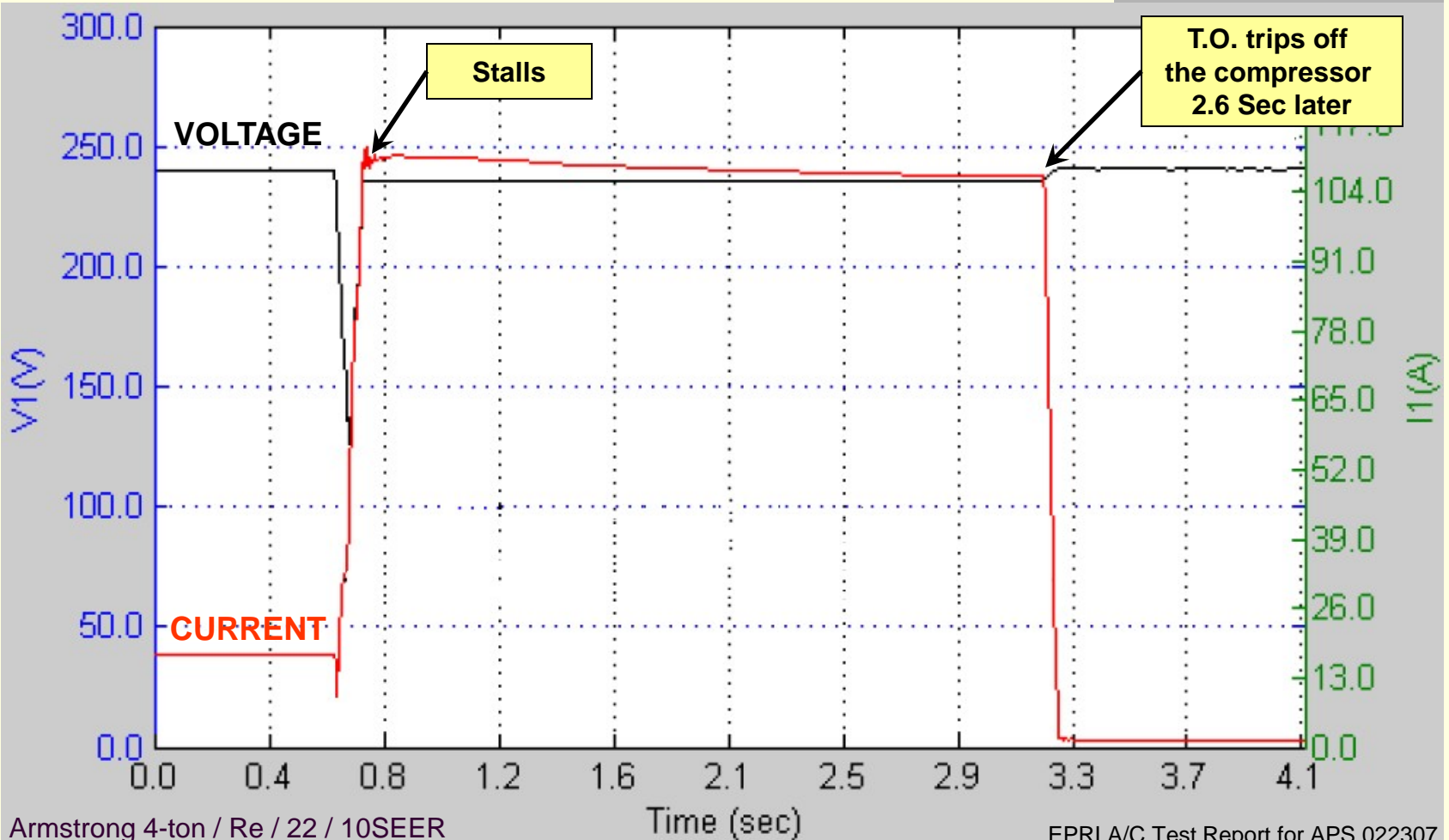
Stall Voltage



Real & Reactive Power (SCE Unit # 5)



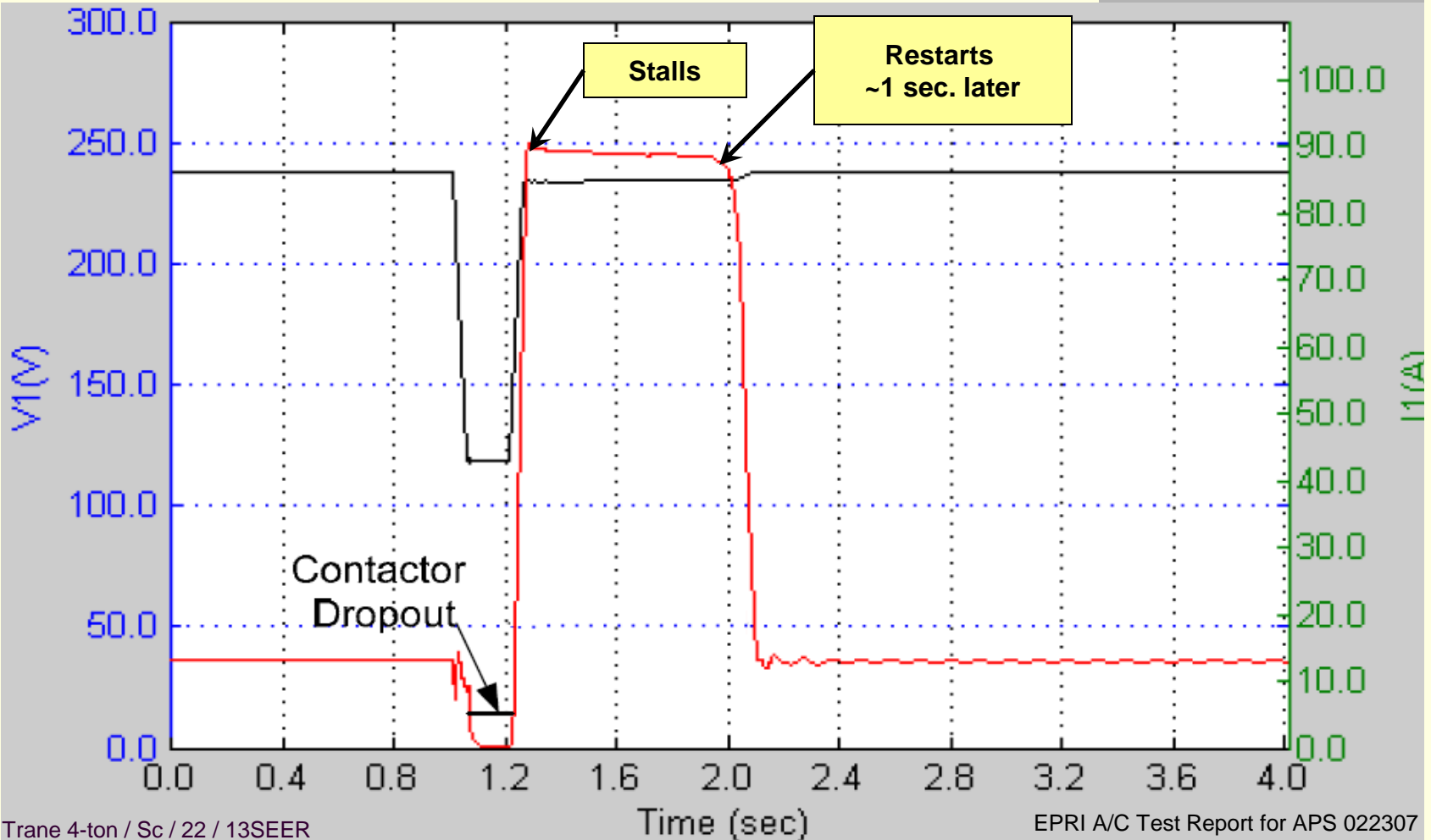
53%-UV for 3-cycles @ 80F



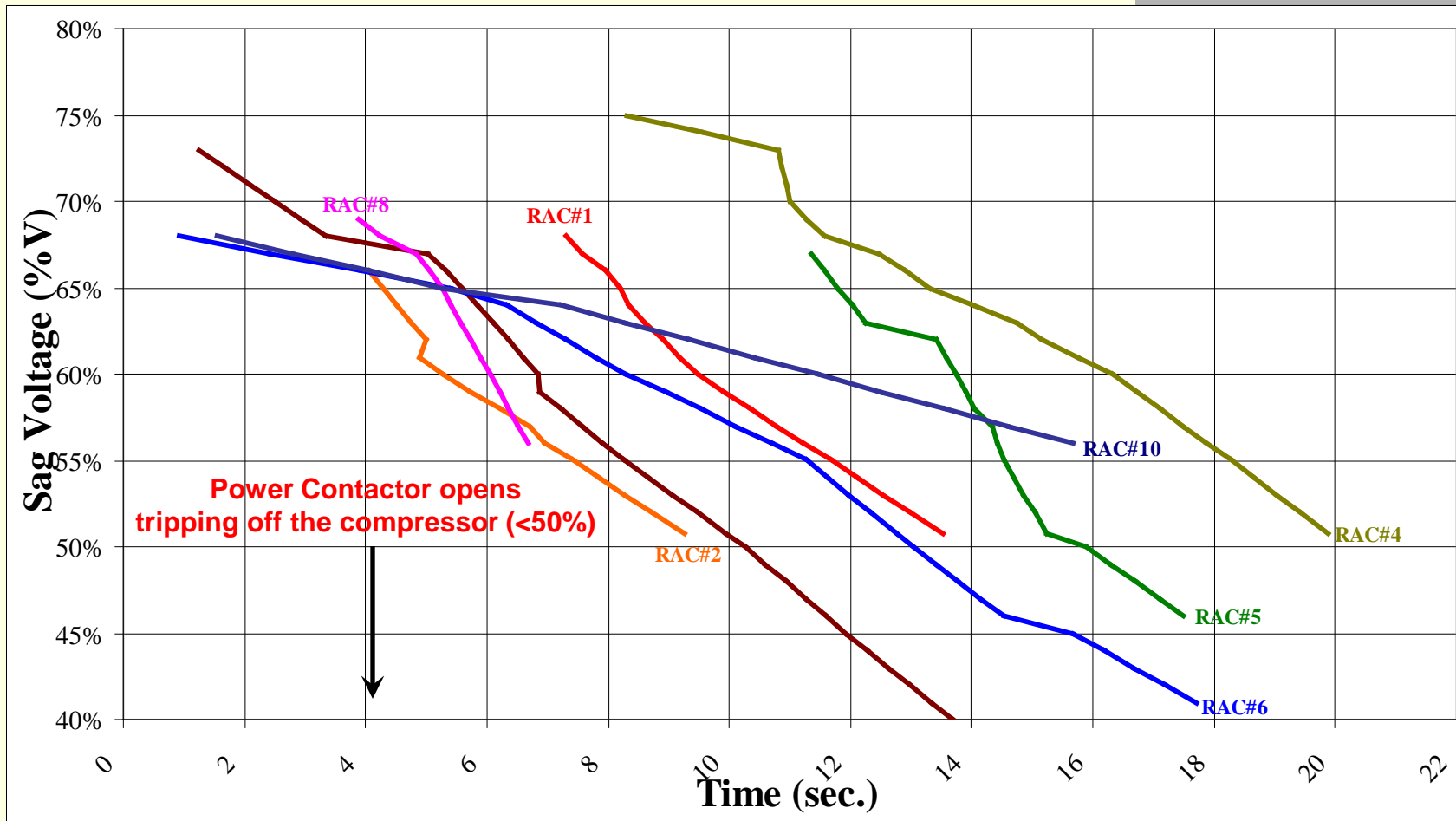
Armstrong 4-ton / Re / 22 / 10SEER

EPRI A/C Test Report for APS 022307

50%-UV for 12-cycles @ 80F



Thermal Protection Tripping Time



A/C Test Summary

- Test confirmed A/C stall conditions
- Stall voltage dependent on outdoor temperature
 - **80F**: 60% of 240 VAC
 - **100F**: 65% of 240 VAC
 - **115F**: 70% of 240 VAC
- Stalls on UV transients as fast as 3-cycles
- Thermal protection switch opens several seconds into the stalling condition (2 to 24 sec.)
- Some A/C units with scroll compressors restart several seconds after stalling
- Power contactors delay stalling for voltages below 50%

A/C Unit Level Solutions

A/C Unit Level Solutions

Pros:

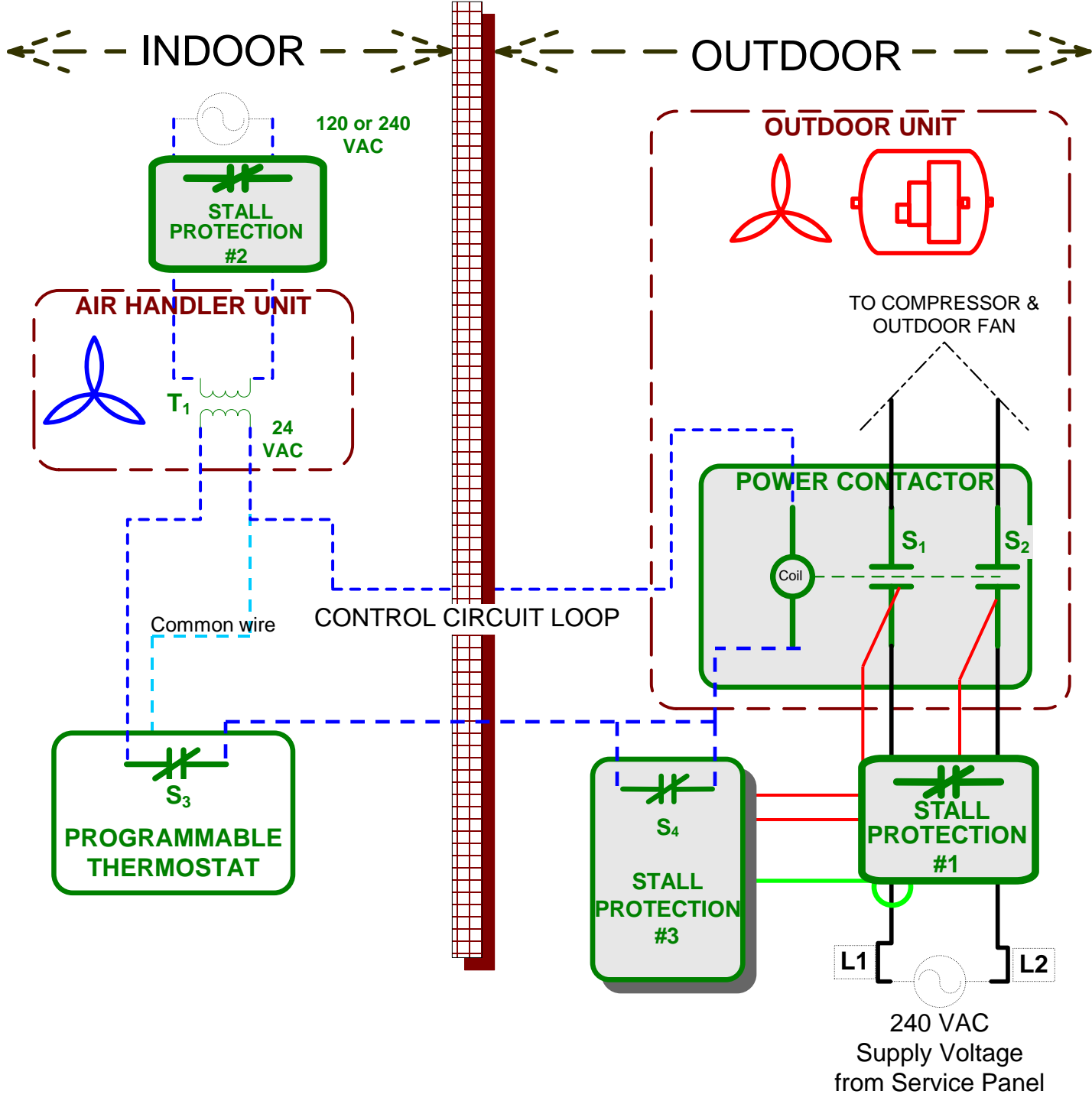
- Solve problem at its source
- Limits low voltage period
- Prevents spread into other areas
- Minimal inconvenience for customers
- Easier to implement in new A/C installations

Cons:

- Need to be installed at many locations
- Labor can be costly for retrofit
 - California requires a certified electrician for circuits greater than 100 VA

Tested A/C Unit Level Solutions

- Under-voltage relays (UVR): 7
 - 4 off-the-shelf
 - 3 development stages
- Load control switch (LCS): 1
 - Off the shelf with revised software
- Programmable digital thermostats: 3
 - Off-the-shelf



Stall Protection #3

Device location:

- Control Loop (24 VAC & <1Amp)

Pros:

- Opens the control loop that will shut down the compressor
- Air flow in the cooling coils is maintained
- Customer will not notice for several minutes
- Thermostat will not be shutdown

Cons:

- Requires a certified electrician to sense the 240 VAC
- Only thermostats might not require a certified electrician

Off-the-shelf UV Relays

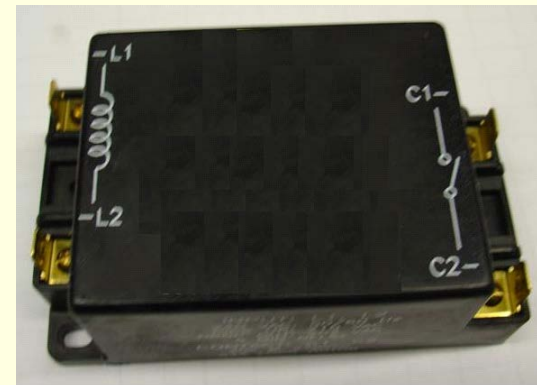
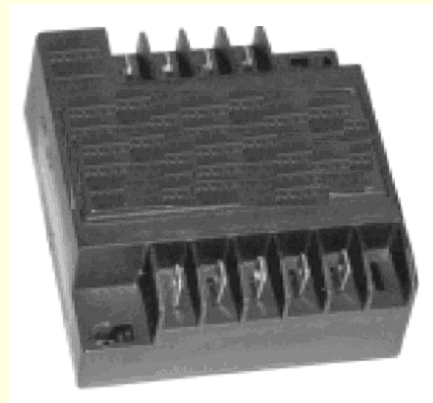
Pros:

- Off-the-shelf devices

Cons:

- Does not protect for fast transients
- Does not come with A/C unit
- Expensive
- Require a certified electrician for its installation

UV Threshold	Response time	Restart Time
86%	4.8 sec.	6 sec.
68%	0.3 Sec.	2 min.
83%	0.5 sec	5 min.



LCS with UV Protection

Pros:

- In the market but need software revision

Cons:

- Expensive
- Technology phasing out and will be replaced by PCT (Cal. Title 24)
- Need a certified electrician (circuit >100 VA)



Thermostat with UV Protection

Test results:

- Only one thermostat had some UV protection

Pros:

- Easiest retrofit implementation
- Do not need a certified electrician

Cons:

- Older units (<1995) might not be protected because lack of power common “C” wire



Solutions Test Summary

- There are no UV relays that can mitigate the A/C stall in the market today
- Some devices with UV protection have limited stall protection
 - Slow response time
 - Voltage protection not set properly
 - Restart time too short or not randomized
- Willing to work with manufacturers to develop stall protection devices

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