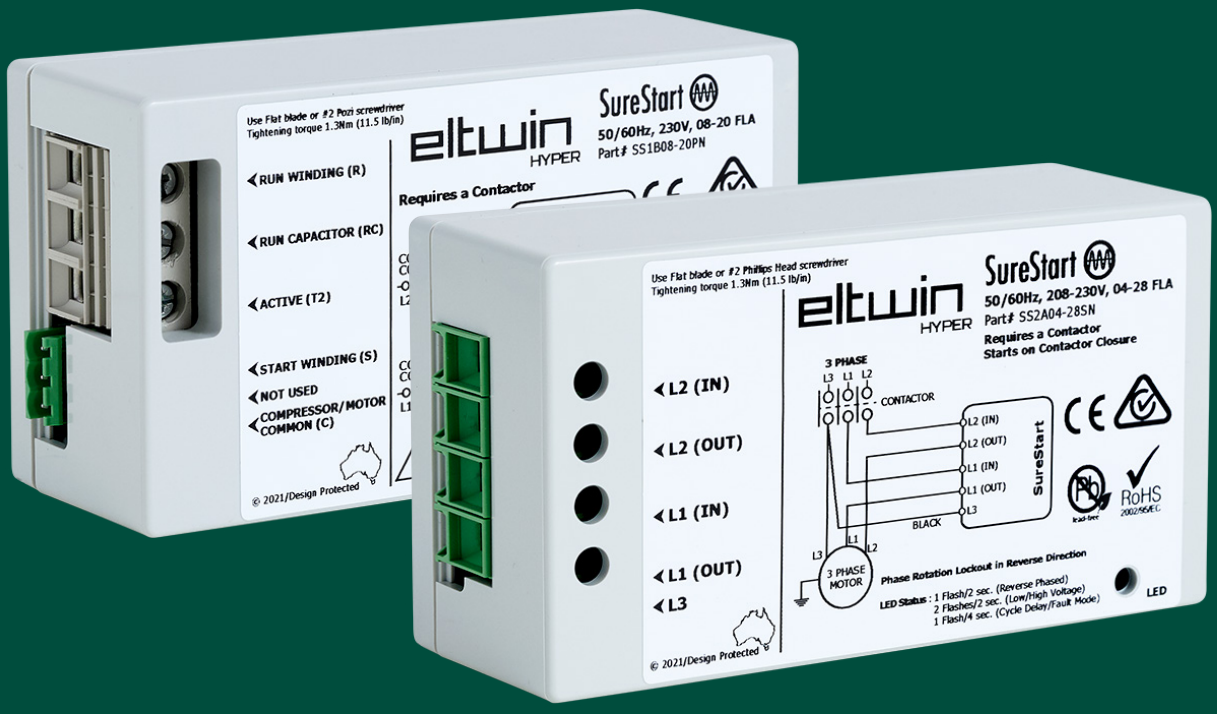
Comparison of Hard start and Soft start technology for single phase HVAC compressors



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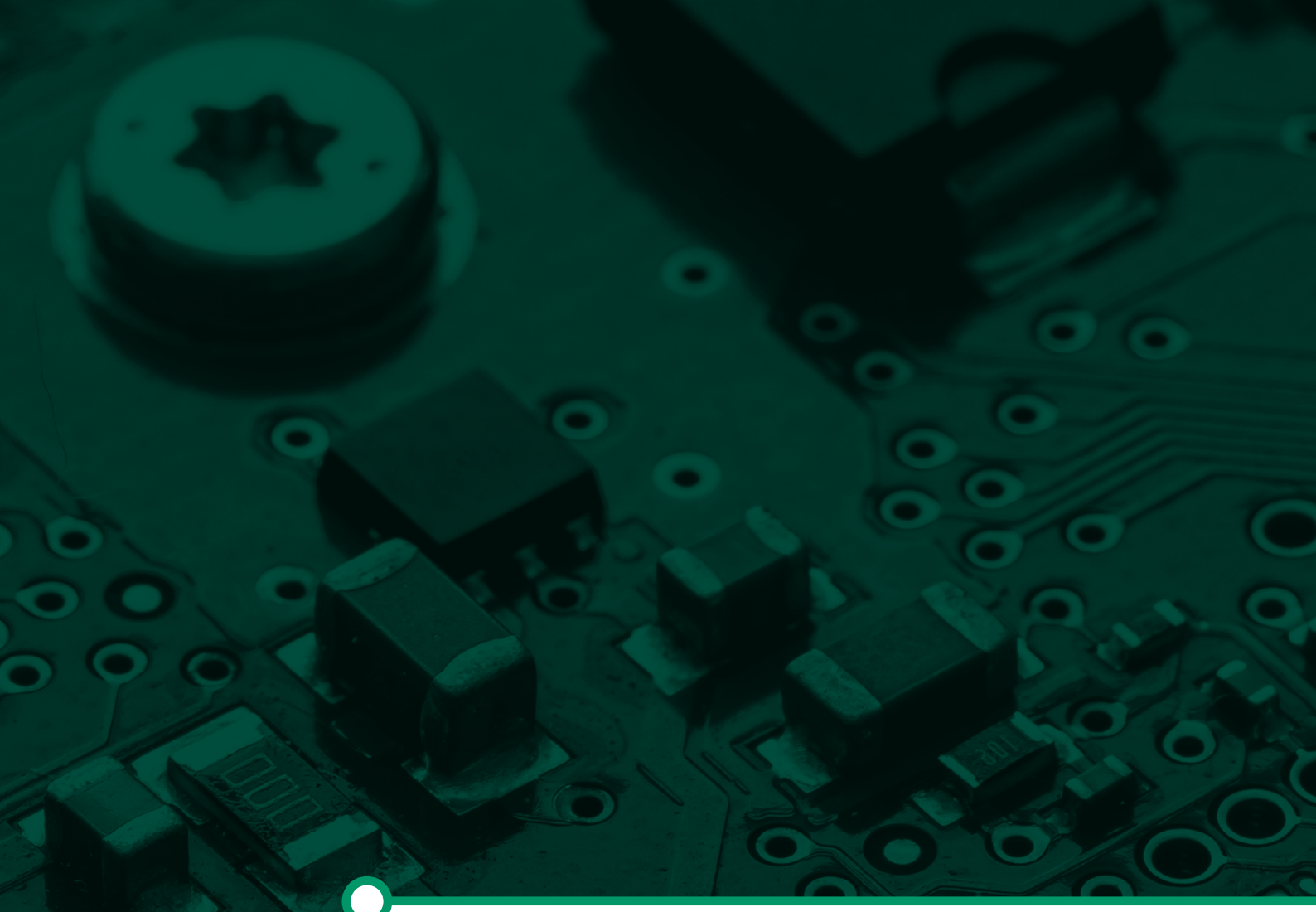


1. OVERVIEW

Typically, single phase compressors used in HVAC industry are permanent split capacitor (PSC) type motors for ratings above 0.5kW and above. A number of start assist devices are readily available in the market today.

This article shall deal with discussing various starting options, focussing more into hardstart and softstart technology. A comparison is drawn elaborating the advantages and disadvantages of both techniques.

The discussion does not include variable speed or inverter controlled compressors. Inverter drives are a modern day superior alternative. However in retrofit applications, their bulky design and higher costs can be prohibitive. So, it has not been discussed in this paper

2. START ASSIST OPTIONS FOR HVAC COMPRESSORS

2A. Run capacitor only - No Assist

This is the minimum option. A compressor can certainly operate for life in this mode. At start, the run capacitor provides the minimum starting torque needed to start the motor. The other role of run capacitor is to improve motor efficiency and power factor. So, a compromise must be struck. These are permanently wired into the operating circuit. This minimal configuration can be used irrespective of the size of the HVAC application.

The start current drawn by the compressor is close to manufacturer listed Locked Rotor Amperage (LRA). In small sized applications, it is not a concern. As the compressor size increases, it puts a burden on the supply to provide the large starting inrush current. Off-grid HVAC applications limited by generator sizes often suffer from starting issues. Also, in network with poor supply impedance, customers may experience light flicker.

2B. PTC across Run capacitor

PTC (Positive Temperature Coefficient Resistor) are typically only used in low horsepower applications (less than 2kW) due to thermal limitations. PTC is connected in parallel to the run capacitor. PTC has low resistance when it is cold and allows a large current to pass through start winding which marginally increases the torque to start up. The large current draw begins to heat up the PTC and it rapidly increases in resistance as the compressor gains full speed. In running condition, very little current is drawn through the PTC resistor. For marginally designed systems, PTCs are low cost and have low performance. PTC are mostly popular for fridge compressors.

PTCs suffer from inability to restart immediately due to prolonged thermal delays. Their characteristics are also extremely hard to match to a given motor rating.

Given its limitations, PTCs are almost considered impractical for modern applications.

2C. Hard start kitt

Hard start kits are more preferred in applications where the system design requires high starting torque. In small sized applications (less than 1.5kW), Reciprocating and Rotary compressors that must start against a pressure head and may require a device to increase the starting torque. If the HVAC unit utilizes a Scroll compressor, hard start kits are not normally required.

A Hard start kit is typically a combination potential relay and start capacitor.

The potential (voltage sensing) relay is used to connect the start capacitor in series with the start winding. Electrically, it gets connected in parallel to a pre-existing run capacitor. The potential relay achieves this by sensing the voltage across the start winding. The contacts of potential relay remain closed normally. As power is applied, the start capacitor is connected in circuit to assist the compressor. As the motor approaches full speed, the voltage across the start winding picks up and forces the start capacitor to disconnect away. The start capacitors carry a high microfarad value and are designed to intermittent service only. Note that a bleed resistor must always be connected across the start capacitor else it will result in sticking of the relay contacts leading to erratic operation and possibly premature failure.

Hard start kits cannot optimise their start-up to varying voltage conditions. The high inrush current also generates large mechanical shock which can stress compressor bearings, potentially reducing their life and creating banging noise at each start.

2D. Electronic Soft starter

Electronic soft starter is a sophisticated and intelligent device designed to reduce the starting current of the compressor by actively controlling the current in both the run and start windings. They actively (phase control) limit the current through run winding while a balanced value of start capacitor is connected in situ to provide the optimal torque required to start a compressor any operating voltage. Along with soft starting, electronic soft starters also provide a substantial number of built-in features to pre-emptively protect the compressor under abnormal circumstances.

Softstarters are particularly well suited for off-grid generator or inverter based HVAC application where limited capacity of source rating and cable impedances over large distances can imply that the compressor simply won't start.

3. COMPARING THE OPTIONS

3A. FUNCTIONALITY

FUNCTION	RUN CAPACITOR [ONLY]	HARD START	SOFT START
Start Current Reduction	NIL	NIL	SUBSTANTIAL
Net Inrush Current	100% OF LRA	110-130% OF LRA	30-40% OF LRA *
Start Duration	250-500 ms	150-400 ms	250-500 ms
Starting Torque	100%	130-200%	AUTO-ADJUST 70-110%
Preventive Lock up at Failed start	Upto 15 s	Upto 15 s	Less than 0.7s*
Mechanical shock at startup	LOW	HIGH	LOW
Durability of Start Assist Device	HIGH	AVERAGE	HIGH
High Start torque applications	NOMINAL NOMINAL	EXCELLENT	NOMINAL

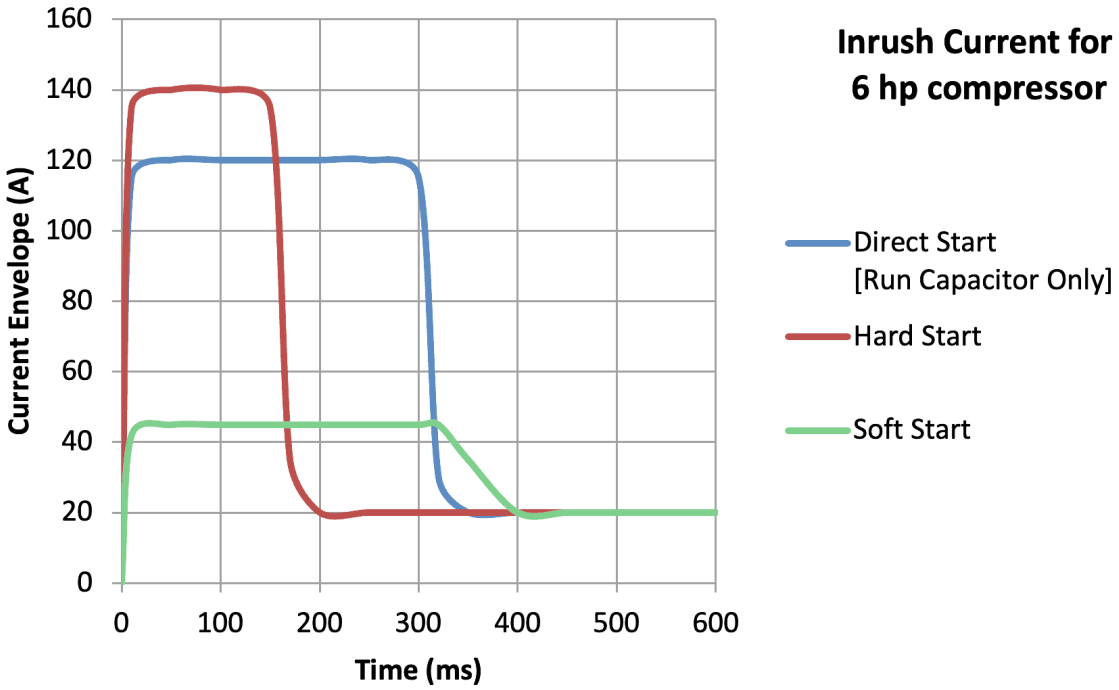
** Reference values based on performance of SureStart brand manufactured by Eltwin Hyper*

3B. KEY FEATURES

FEATURES	RUN CAPACITOR [ONLY]	HARD START	SOFT START
Performance in low voltag conditions	AVERAGE	POOR	EXCELLENT
Start-up performance on Generator	POOR	POOR	EXCELLENT
Light Flicker Nuisance	POOR	AVERAGE	IMPROVED
Low voltage Stall protection	NO	NO	YES
Auto-adjust to variable supply voltage	NO	NO	YES
Auto-adjust to various compressor sizes	NO	NO	YES
Reverse rotation Protection	NO	NO	YES
Improve compressor life	NO	NO	YES
Protection from Rapid cycling	NO	NO	YES
Compliance with Inrush Current Regulations	NO	NO	YES

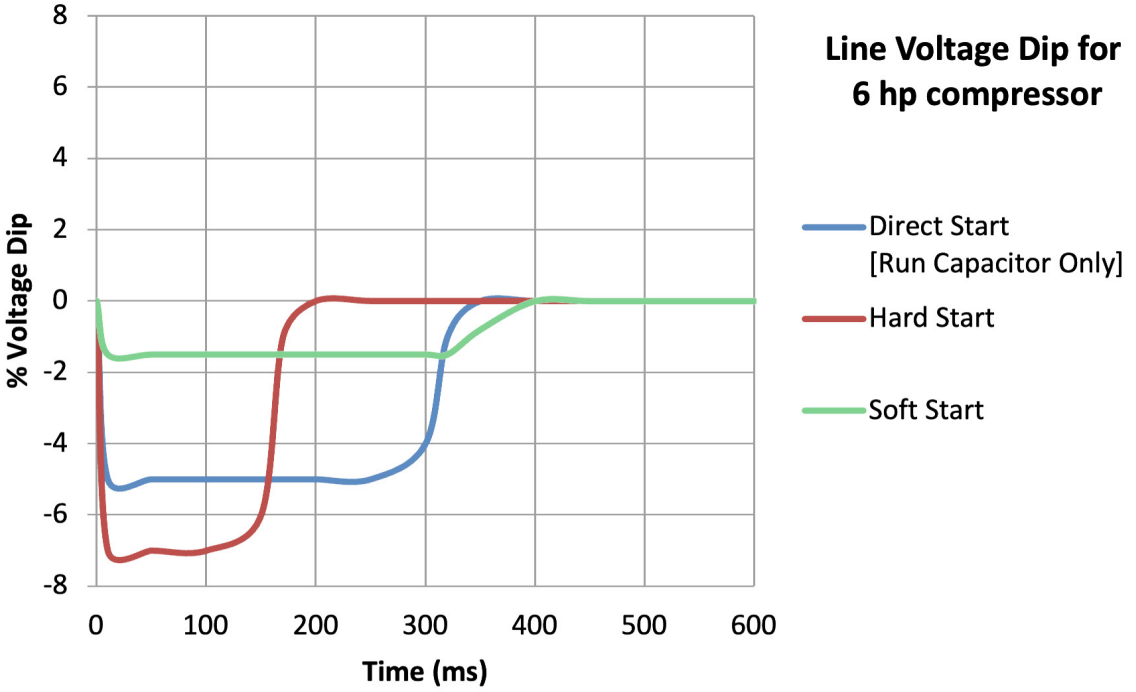
3. COMPARING THE OPTIONS

3C. GRAPHICAL COMPARISON



START CURRENT REDUCTION

3B. KEY FEATURES



SUPPLY VOLTAGE DIP

4. REALITY CHECK FOR HARDSTART KITS

4A. TEMPTATION FOR LOW COST SOLUTION

The lower cost of Hard start kit is appealing however their simplicity can also be a trap when operating conditions are abnormal. For example, a low voltage (brown-out, a random event) occurs, the simple potential relay voltage detecting threshold may not be reached and the low duty rated start capacitor is left connected for too long and it overheats and fails; hopefully before permanent damage is done to the compressor motor's start winding. Some modern hard start kits do come with time controlled switching of relay to avoid this.

4B. COMPRESSOR LIFE MYTH

There is also misdirected claim that they increase the life of compressor. Forceful means of a hard start kit is only justified on high start torque applications else it can wear out compressor bearings and rotating parts sooner than its desired operating life.

Also, it adversely affects the life of the HVAC unit. The compressor assembly is directly subjected to a far higher accelerating shock to its internal bearings, the external foot mounts and interconnecting pipework. Accelerated pipe fractures can occur after some years of service resulting in total loss of refrigerant and higher repair costs. Additionally, the owner may clearly notice an increase in the start-up noise.

4C. ENERGY SAVING MYTH

A HVAC compressor can experience on an average 5000 starts in a year. As hardstart kits accelerate the start by 100ms, total start time reduction accrued over a period of one year would be less than 10 mins. The resulting energy savings is negligible and equates to cost savings of under $1/year.

4D. RAPID CYCLING CONCERN

Hard starts cannot protect against motor damage by counting starts per hour. They are very simple devices that rely on all operating conditions remaining "normal". When things do go wrong they can both fail and also damage the compressor winding with it.

4E. MISLEADING PROTECTIVE FEATURES

Claims made by some Hard start manufacturers are misleading. For example: “Voltage Sensing” is a common claim. This is perceived as a protective feature, yet no protection is provided. It simply refers to the potential relay based operating mechanism of the kit.

4F. FLIGHT FLICKER

If light flicker is a problem, a Hard start may help reduce the visible effects as the motor winds up to full speed faster. However they do not reduce the magnitude of the voltage dip which can still lead to nuisance circuit breaker tripping or equipment malfunction/resets.

5. SUMMARY

Compressor health is often the single biggest concern in any HVAC application as replacing faulty compressors can be quite labour intensive and expensive.

Considering the abundance of protection as compared to any start assist techniques, Electronic soft starters are an economical and valuable proposition for compressor starting and protection.