AoFrio

USER MANUAL

SCS Controller

Variable Speed Control

for Compressors

Guide for physical connection and SCS configuration

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Summary

This document describes the requirements for connecting and controlling a variable speed compressor with SCS Controller.

Please refer to the manual for SCS Standard Features (WT9748) for technical specifications and more detail about the Rear Connector Panel.

SCS Firmware

The information provided applies only to SCS firmware that includes the Variable Speed Compressor control (VSC) functions.

This currently (December 2023) includes:

- 4022 beta test versions
- 4024 pre-release

Power supply specifications and limits

The SCS can be configured to output a nominally 5V PWM single through Port AD4.

PWM output properties	Min	Max	Unit
Frequency range	30	1000	Hz
Duty	50	50	%
Output voltage	Refer AD4 rating		

WARNING: The external peripheral must not draw more than the rated current from this port or the SCS may be permanently damaged.

| SCS Port AD4 Rating	Min	Max	Unit
5V Output current (SCS versions <u>without</u> internal LED display)	-	100	mA
5V Output current (SCS versions <u>with</u> internal LED display)	-	80	mA
5V Output voltage	4.6	5.1	V

VSC Signal Connection (and examples)

Here are three options for connecting an SCS Controller to several combinations of system components while maintaining complete power measurement.

What you should know

- Each of these configurations is dependent on features added in SCS Firmware r4024 that allows a designated port to remain continuously enabled so load current can be measured by SCS.
- Direct frequency control of the Compressor Inverter is generated as a 5V square wave from port AD4. This signal should be compatible with any inverter that provides an isolated frequency input where 5V is sufficient to trigger the input to logic state "1".
- The variable speed compressor requires connection to SCS port AD4 for the 5V signal output.
- AD4 is a 3-way Stocko connector with Pin 1 GND and Pin 3 +5V VSC signal output (when configured).
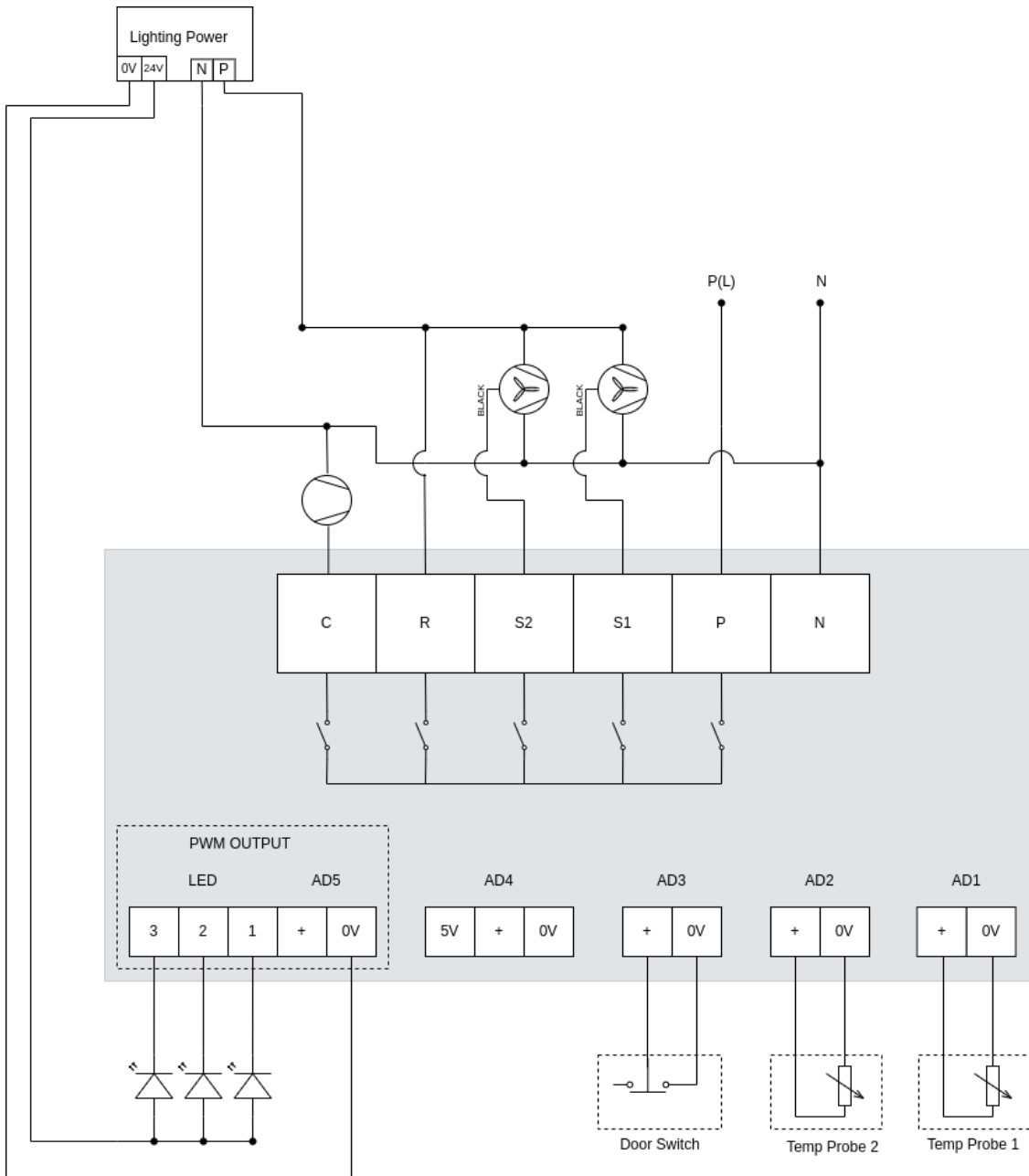
Example 1

- SCS with 2 x ECR2 fan motors in variable speed configuration, variable speed inverter and low voltage power supply for multi-channel lighting
- All devices are powered through the C relay of SCS to achieve power measurement of the complete system
- Resistor on R relay represents optional heating element
- Frequency control is generated using the 5V output on AD4
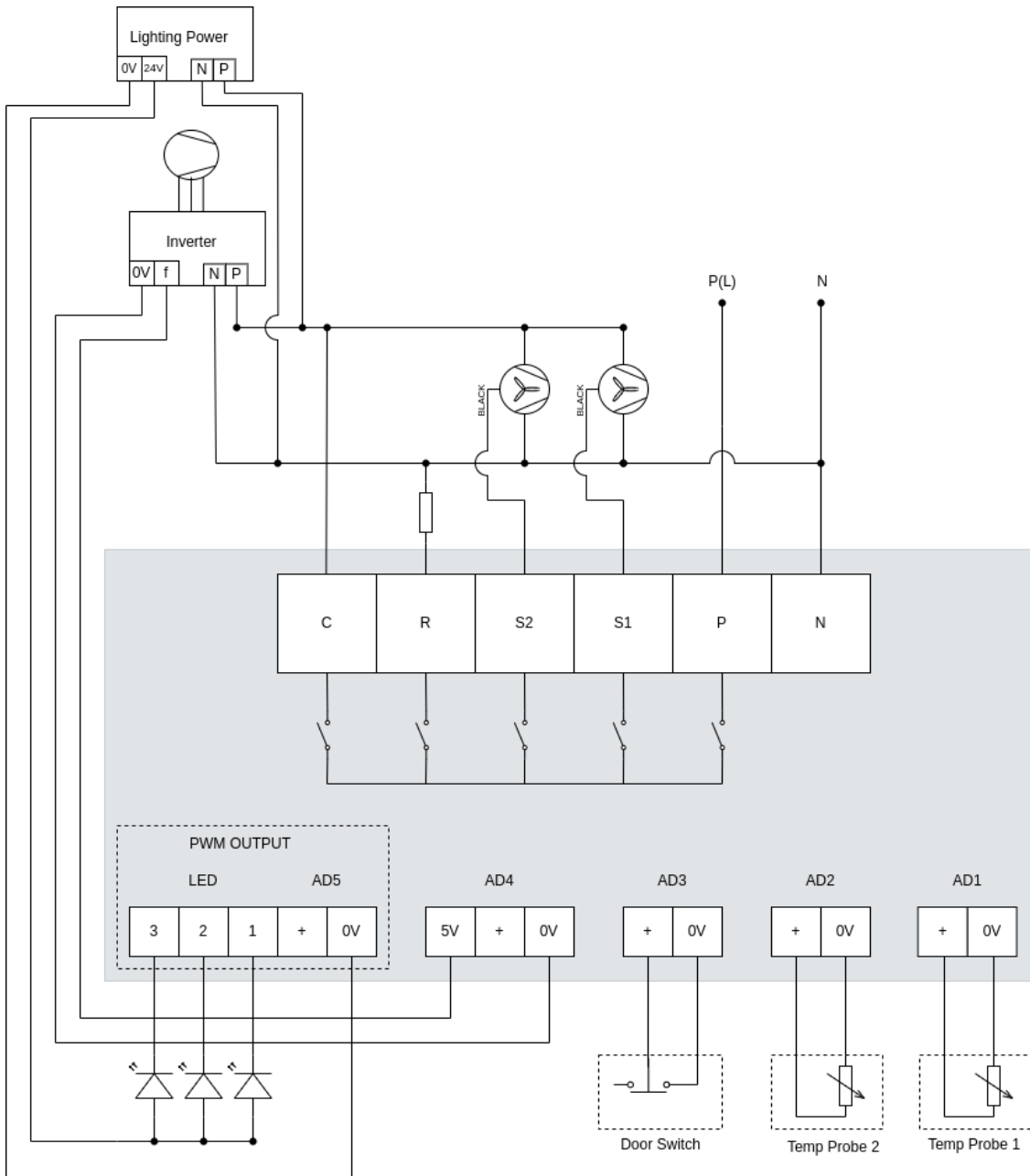
Example 2

- SCS with 2 x ECR2 fan motors in variable speed configuration and low voltage power supply for multi-channel lighting
- ECR2 and lighting are powered through the R relay of SCS to achieve power measurement of the complete system
- This configuration <u>cannot</u> provide an output for a heating element

Example 3

- SCS with 2 generic EC fan motors and low voltage power supply for multi-channel lighting
- Inverter and lighting are powered through the C relay of SCS to achieve power measurement of the complete system
- Resistor on R relay represents optional heating element
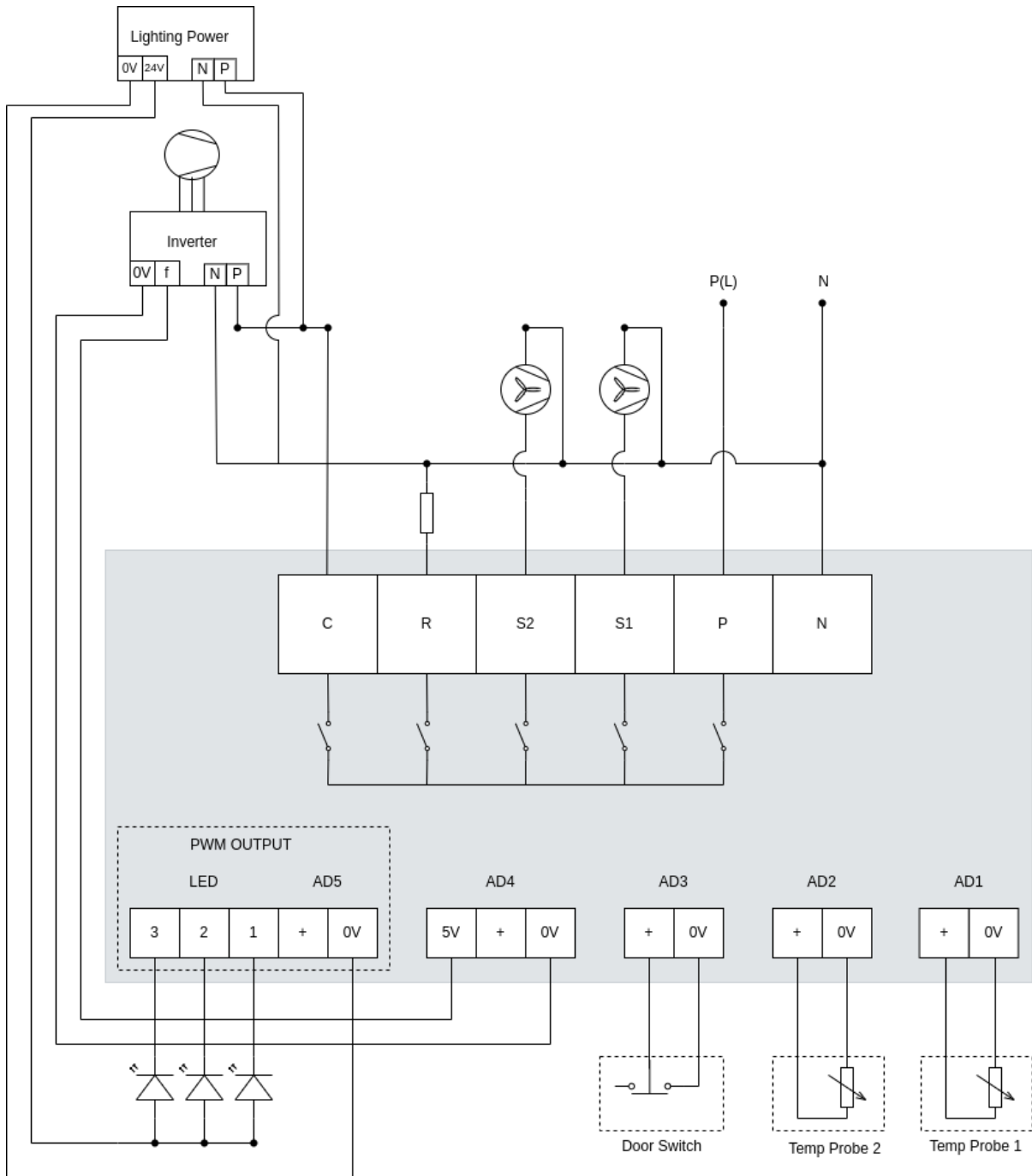- Frequency control is generated using the 5V output on AD4

Configuration parameters

Activation of the Variable Speed Compressor functionality and tuning of performance is achieved using a combination of newly added parameters, and extended options for existing parameters.

Correct values for each of the frequency parameters must conform to the requirements of the model of VSC being used. The default values for these parameters are based on the frequency input scheme presented by Embraco models, but other brands may differ.

New parameters introduced in 4022 directly related to control of variable speed compressor.

Title	Units	Minimum	Maximum	Description
VSC Stop Freq	Hz	0	255	Frequency sent to inverter to halt compressor operation
VSC Minimum Freq	Hz	0	255	Minimum frequency allowed during stepping control
VSC Maximum Freq	Hz	0	255	Maximum frequency allowed during stepping control
VSC Step Interval	Sec	10	255	Time in seconds between frequency step changes
VSC Increase Step Freq	Hz	1	100	Size of each frequency step increase
VSC Decrease Step Freq	Hz	1	100	Size of each frequency step decrease
VSC Hot Gas Defrost Freq	Hz	0	255	Frequency requested during hot gas defrost
VSC High Temp SP Differential	temperature offset (above Set Point)	0.1	20	Offset above Set Point for the upper limit of the frequency stepping band
VSC Low Temp SP Differential	temperature offset (below Set Point)	0.1	20	Offset below Set Point for the low limit of the frequency stepping band. Below this band, the compressor will shut down.
"Always On" port	Port selection	from:C,R		Port selected as unconditionally switched on to allow power measurement of non-switched components. Note: In the event of a terminal alarm, this output will be disabled until the alarm condition is reset.

Existing configuration parameters with extended options

Title	Units	Minimum	Maximum	Description
Evaporator Fan Control - Normal	Mode selection	0	6	New mode 6 Allow Evaporator Fan to run while compressor on, and timed cycle on/off while compressor off

Events and Statistics Logging

Support for the features described in this document require SCS r4024b8 (FW version) or greater. This will log one additional statistic - Maximum compressor frequency during logging interval

Events are also logged for frequency up/down steps, although these will likely be removed for full release.

Compressor Frequency Control Algorithm

SCS FW 4022b implements a simple mechanism for adjusting compressor frequency according to observed demand.

The intention is that in all cases, unless otherwise stated, the firmware will behave according to normal SCS functionality.

Description of Frequency Control Method

The basis of the frequency control system is to perform time-based increased and decreased frequency steps determined by the comparison of the control temperature (i.e. Return Air temperature) against the currently active temperature set point.

Note: "Currently active set point" is important, because allows the control scheme to operate during energy-saving modes where the set point may be increased from the Normal Mode value.

The table below shows the control response to each possible temperature range.

where:

- Tra = Return Air Temperature
- Tsp = Active Temperature Set Point
- Toffset = Active Temperature Control Offset
- HTO = High Temperature Offset
- LTO = Low Temperature Offset

Frequency Control Method

Force Stepping?	Operating Temperature Band	Resulting Frequency Change	Other Actions
TRUE	ANY	Step increase	
FALSE	$Tra > (Tsp + HTO)$	Maximum speed	
FALSE	$(Tsp + Toffset) < Tra < (Tsp + HTO)$	Step increase	
FALSE	$Tsp < Tra < (Tsp + HTO)$	Hold (no change)	
FALSE	$Tsp < Tra < (Tsp + HTO)$ [for > 20x interval]	Hold (no change)	set "Force Stepping"
FALSE	$(Tsp - LTO) < Tra < Tsp$	Step decrease	
FALSE	$(Tsp - LTO) < Tra < Tsp$ [for > 20x interval]	Step decrease	set "Force Stepping"
FALSE	$Tra < (Tsp - LTO)$	Turn off compressor	

- As is the case for standard SCS, cooling is activated when the measured temperature goes above the "Ton" temperature - that is the $Tsp + Toffset$

- Unlike standard SCS, cooling is terminated, not by Tra reaching Tsp, but when Tra is less than Tsp - LTO

Effects on other SCS Functions

- **Defrost**
    - Defrost initiation and termination by temperature or time is not directly affected by the use of compressor frequency control.
    - Optimal configuration of frequency control may reduce the frequency of required defrost cycles, so adjustment of defrost settings could provide an opportunity for further power saving.
- **Power measurement**
    - System power measurement using the SCS will not be possible if the inverter power is wired independently.
    - To address this issue the inverter should be powered from the C relay of the SCS and the "Always On" component configured to supply power to this output at all times.
    - If using ECR2 fan motors in variable speed configuration, these may also be powered from the C relay so their power use can be measured by SCS.

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