Release Summary: FW-4020 Firmware update

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Summary

AoFrio is releasing a new version of SCS Controller firmware – FW-4020.

FW-4020 merges all previous versions of SCS Controller firmware into this one new FW-4020 version. It also makes changes to the controller parameters, including the introduction of a new parameter "Install Type" and other configuration options which are described in detail below.

This FW-4020 release also introduces a new firmware file format which packages all of the firmware components required in a release together into a .zip file. In conjunction with the new AoFrio app releases this new file packaging improves the firmware update process and simplifies all future AoFrio SCS controller firmware updates.

FW-4020 works with all the latest released versions of Cradle, Lab, Track and Field apps. However - if you are using older versions of these apps then some issues may be observed. Please contact AoFrio Support if you have any issues or queries around this.

Changes you'll see in this update

Contents

File formats for this and future AoFrio firmware releases

AoFrio (or Wellington Drive Technologies) previously released all FW updates for the SCS as single binaries in the format "SCS_[type]_[hw-version]_[fw_ver]_[build].bin".

Example:

SCS_0000_1593_9.bin

where

- *[product]*
  - *SCS for the SCS controller*
- *[type] is one of*
  - *OTA - Main FW only*
  - *DUAL - Main FW and High-side FW*
- *[hw-version] is one of*
  - *0000 - SCS Adv or SCS Basic*
  - *0002 - SCS Adv no display*
  - *0003 - SCS Basic no display*
- *[fw_ver] is of the format*
  - *15xx - General code*
  - *161x - Custom code*
  - *162x/163x - Freezer and custom code*
- *[build] is of the format*
  - *from 1 to 99*

For this FW-4020 update, and all future FW releases, AoFrio will release updates as ".zip package" files containing multiple binaries. This allows the single package file to update the various chips on an SCS controller, and also contains multiple "Main FW" binaries which are selected based on the hardware (HW) version. This is explained in detail later in the document.

The new FW .zip packages will follow this format:

- When only one FW version exists in the .zip
  - [product]_[fw_ver]-[build].zip
- Where two FW versions exist in the same .zip
  - [product]_[fw_ver1]-[build1]_[fw_ver2]-[build2].zip

Examples

SCS_4020-6.zip
SCS_1595-6_4020-25.zip

Note. The .zip files are password protected for security purposes to prevent the package from being unzipped and used incorrectly.

Expected time to update FW-4020

When using Field app, if the Bluetooth connection between the mobile device and SCS controller is strong and uninterrupted then it should take no more than 5 minutes for each SCS controller to update to the whole FW-4020 package. If there are interruptions, or a weak signal then the update may take longer.

Handling software and SCS hardware variants

Unlike the earlier FW-4010 release where there were different FW versions and package files, the FW-4020 release contains all the functionality for all previous firmware versions across all hardware variants (exception below).

The exception is for a limited quantity of controllers released in 2015 labelled with part number SCSMC which cannot be updated to FW-4020.

Automatic updates for High-side and BT-Chip firmware

The FW-4020 will bring some automatic changes to the way High-side and BT-Chip FW are updated. This relates to the three micros on the SCS:

o   Main Micro - Contains all the control logic
o   High Side - Deals with power, voltage and current measurement and variable speed control of fans
o   BT Chip - deals with all the BT communications

In the past, the situation was as follows:

o   Binary type OTA would ONLY update the main micro
o   Binary type DUAL would ALWAYS update the High Side micro and Main micro
o   BT-Chip could not be updated

After installing the FW-4020 update, which contains all three micro binaries in the .zip file, it will ALWAYS update the Main micro, but will also check the version of the High-Side and BT-Chip FW, and if it is older than the one in the .zip file, it will ALSO update that. As this is automatic, no further action is required by the customer.

Downgrading to earlier FW versions

When AoFrio released FW-4010 in early 2023, it changed the way parameters are mapped to create more space for additional parameters to be added. FW-4020 is designed to assess, translate, and map parameters to this new logic in any devices that have firmware that pre-date FW-4010.

For certain SCS models (detailed below), it is possible to downgrade firmware using Cradle or Lab app as these apps have the functionality needed to make a "factory reset". Field app doesn't have the functionality to downgrade devices that already have Firmware 4000+ (eg 4010, 4020 and beyond) to an earlier version of firmware. As this could corrupt the file, AoFrio has put blockers and notifications in place in the latest version of Field app to avoid any accidental downgrade attempts.

- **Older SCS controllers (e.g. with older micro)** do not support FW-4000 to FW 4019 so if they already have FW-4020, you cannot downgrade them below FW-4020 with Cradle, Lab or Field.
- **Newer SCS controllers (e.g. with newer micro, "AM" sticker on outer casing)** support FW-4000 upwards but do have a parameter database difference between FW-4000 and FW-4010. You can downgrade these models to FW4000 with Cradle or Lab app (as it resets the database) but you can only downgrade to FW-4010 with Field app

Introducing a new parameter called 'Install Type'

The FW-4020 update introduces a parameter that is new to anyone not already using the 162x/163x FW version. The 'Install Type' parameter will be the first option that you can see in the Normal Parameter Menu and is different to all other parameters.

This special parameter allows the SCS controller to operate using different logic, display different app visuals and adjust parameter visibility or write-ability. It supports various operation types that were previously managed through different code versions.

Every SCS controller is configured with the 'Install Type' parameter default setting as "undefined". You can leave the parameter "undefined" OR choose to update as follows:

Functionality	Item	Install Type Parameter				
		Undefined	**Bottle Cooler**	**Horizontal Freezer / Upright Freezer**	**Custom 161x**	**Custom 162x**
Control Logic	Operational Setpoint	-35degC to 20degC	-10degC to 20degC	-35degC to -10degC	See Custom specific documentation	See Custom specific documentation
	Standby	available	available	disabled		
	Refrigeration System Failure	fully configurable	fully configurable	disabled		
Parameters	Visible (readable)	As per 15xx FW	As per 15xx FW	Freezer 162x FW	161x	Custom 162x
	Writeable (from a parameter file)	All 15xx, 161x, Freezer 162x, Custom 162x	15xx	Freezer 162x FW	161x	Custom 162x

Once you have selected a setting, the 'Install Type' is displayed on the Field and Lab app home screen.

If the Install Type remains "undefined", then ANY parameter file generated from 15xx, 161x, 162x and 163x can be written to FW-4020 and the FW will then be configured to operate in the same way as FW versions for 15xx, 161x, 162x and 163x.

If the Install Type is changed, for example to the 'Horizontal Freezer' setting, and a parameter set generated for FW version 15xx is used (which will not contain an Install Type), some parameters will be out-of-range for an Upright Freezer (such as the Operational Setpoint). Out-of-range parameters are highlighted as "out-of-range" when written from the Field or Lab app.

Please note: when the parameter set is used on the Cradle app, because the cradle always resets parameters back to factory defaults BEFORE writing a parameter file, the Install Type will be Undefined, so will accept the older parameter set.

Parameter option name changes

Selectable options under two parameters have been updated to help identify functionality without additional need for the user manual.

Parameter Name	New selectable option	Previous option	Description
Defrost Type	Disabled (0), Electric (1), Hot Gas (2), Passive (3), Electric + Fan (4)	0, 1, 2, 3, 4	The numbering remains for historical reference purposes, but the defrost type is now also shown in text form
Perishable Mode	off, on, on+auto, on+manual	off, on, 1, 2	Options 1 and 2 configured the high/low temperature alarm reset functionality, which also sets perishable mode as ON. This has now been described as on+auto - Perishable ON and automatically clears high/low temp alarm on+manual - Perishable ON and high/low temp alarm requires manual clearing

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New parameters and functionality changes

Parameter and functionality changes can be split into those that do not affect refrigeration control logic, those that do, and those that allow increased configurability of existing logic

Non-control logic

The following changes do not affect refrigeration control logic

New Parameter / Functionality	Pre-4020	Description
NTC Type 0-2	NTC Type 1-2	0 = WDTL sensor. This uses a look-up table as opposed to an equation to determine the temperature. This is more accurate at temperatures below -20degC than the equation based approach. 1 = As per NTC1 Beta and Resistance values 2 = As per NTC2 Beta and Resistance values
Display Settings - Defrost Cycle	unused	Selects what is displayed during the Defrost Cycle: 1 = Display the Set Point Temperature. 2 = Display the temperature at the point the defrost started 3 = Display shows 'dEF'. 4 = Display shows 'dEF' during the defrost, but display the temperature at the point the defrost started during DEFROST DISPLAY HOLD TIME
Display Hold Time	not present	The time AFTER the defrost is completed during which the display continues to operate as defined by DISPLAY SETTINGS - DEFROST CYCLE. This time can also be terminated if the return air temperature falls BELOW the temperature from the start of the defrost. When this time expires (or is terminated by temperature), the displayed temperature is "seeded" with the temperature from the start of the defrost. The displayed temperature will then change at the rate specified by the display filter.

New configuration options

The following configurations operate by default as per pre-4020, but are now configurable

New Parameter / Functionality	Pre-4020	Description
No Downwards Tendency Differential	not present	The temperature drop required to have occurred within the NO DOWNWARDS TENDENCY DEFROST TIME to prevent the triggering of a defrost cycle (NDT Defrost). This allows for the configuration of NDT Defrosts at a higher rate than timed based defrost. In addition, the parameter "No Downwards Tendency Defrost Time" now allows 6min resolution, so that the two parameters can support a higher frequency defrost schedule while an evap freeze-up is present

Defrost Control logic changes

There has been some improvements to the defrost control logic to:

- Remove some unnecessary use cases
- Simplify the configuration

New Parameter / Functionality	Pre-4020	Description
Timed Defrost Config **Total** **Comp On**	Defrost Temp Config 0,1,2,3 8,9,10,11	Previously this parameter was called Defrost Temp Config and configured two defrost functionalities. a) Which sensor was used for the defrost initiation/termination temperatures b) Whether timed defrost operated from total time or compressor run time. The independent defrost initiation/termination temperature configuration has been removed and is now defined based on the configuration of the evaporator sensor port. This parameter therefore now only refers to the timed defrost operation **See section "Time Defrost Config" below for a more detail explanation** Timed Defrost Config: Defines whether the MAXIMUM TIME BETWEEN DEFROSTS refers to the total time, or only the time the compressor is ON. This prevents unnecessary defrosts when the compressor is operating on a short duty cycle, as ice can only build up on the evaporator while the compressor is on Total = MAXIMUM TIME BETWEEN DEFROSTS refers to the total elapsed time Comp On = MAXIMUM TIME BETWEEN DEFROSTS refers to only the time the compressor is ON

NOTE: Section continued on next page.

Defrost Control logic changes continued

New Parameter / Functionality	Pre-4020	Description
NDT and Manual Defrost Config Safety Temp, Termination Temp 1-10	No Downwards Lockout Count Disabled, 0 1-10	**See section "No Downwards Tendency" below for a more detail explanation** Determines the temperature based termination behavior of a No Downwards Tendency (NDT) Defrost and Manual Defrost. NDT Defrosts and Manual Defrosts generally only occur in the case of a full evaporator freeze-up to aid in recovery. They are not triggered by normal day-to-day operation. Safety Temp = NDT Defrosts and Manual Defrosts occur for "Max defrost cycle time (dCt)" or are terminated by SAFETY TERMINATION TEMP. They are blocked when triggered above this temperature. Termination Temp = NDT Defrosts and Manual Defrosts occur for "Max defrost cycle time (dCt)" or are terminated by either the DEFROST TERMINATION TEMP or the SAFETY TERMINATION TEMP. They are blocked when triggered above either of thse temperatures. 1-24 = The number of times in a row a NDT Defrost can occur above the termination temp before a "NDT Terminal Alarm" will shut the system down (The count is reset whenever a different defrost successfully occurs). NDT Defrosts and Manual Defrosts occur for "Max defrost cycle time (dCt)" or are terminated by the SAFETY TERMINATION TEMP. They are blocked when triggered above this temperature.
Defrost Safety Termination temperature	not present	**See section "No Downwards Tendency" below for a more detail explanation** The temperature at which ALL defrosts will terminate to prevent an excessive internal temperature causing damage. This applies to both the Return-air temperature and Evaporator Coil temperature (if sensor is fitted and functioning). This allows the exception condition of a "Manual" or "No Downwards Tendency" defrost to terminate at a higher temperature to increase the chances of defrosting of a coil that has not defrosted successfully using the regular "Timed" and "Temperature" based defrost profiles. This does include "Manual" and "No-Downwards-Tendency" defrosts.

Timed Defrost Config

In pre-4020 Firmware, an advanced parameter Defrost Temp Config supported two defrost related functions

1. Which sensor was used for the defrost initiation/termination temperatures
    1. Defined by bit 0 and 1 of the parameter (binary xxxx xx10)
2. Whether timed defrost operated from total time or compressor run time
    1. Not available on all FW versions
    2. Defined by bit 4 of the Parameter (binary xxx4 xxxx)

Defrost initiation/termination temperature

Defrost Temp Config allowed the independent selection of the Return-air or Evap probes for defrost initiation and termination. This was however an unnecessary and overly complicated combination of selections. Instead, the unnecessary selection options have been removed, and the defrost initiation/termination temperature used is determined solely by whether an evap probe is configured as present or not (This is equivalent to the setting of 3 [binary xxxx xx11] in Defrost Temp Config). The premise is that

- Defrost initiation from ret-air sensor is not a valid use case, so if defrost initiation is enabled, it always uses the evap probe
- If an evap probe is present (typically the case in electric and hot-gas defrost systems) and defrost termination is enabled, the evap probe is a better determination of evap coil temperature (so termination based on ret-air is redundant)
- If there is no evap probe (typically in passive defrost systems), defrosts can still be terminated by temperature when the internal case temperature is high enough

Timed defrost source

Defrost Temp Config (on some FW versions) also allowed the selection of whether the "Maximum Defrost Interval" referred to the TOTAL time, or only the time the compressor was running for (so if the compressor was on for 50% of the time, it would take twice as long between timed defrosts).

This functionality is still valid, so the Defrost Temp Config parameter has been renamed as Timed Defrost Config with the following options

- Time (equivalent to 0,1,2,3 in Defrost Temp Config)
- Comp On (equivalent to 8,9,10,11 in Defrost Temp Config)

Parameter	Defrost Initiation configuration			Defrost Termination configuration		
	Pre 4020		New 4020 parameter / functionality	Pre 4020		New 4020 parameter / functionality
	ret-air	evap		ret-air	evap	
Evap Coil Temperature Port = NC	Uses ret-air (Not a valid use-case)	Uses ret-air (Not a valid use-case)	Disabled No initiation	Use Ret-air	No Termination (invalid config as no evap sensor)	Use Ret-air
Evap Coil Temperature Port = ADx	Use ret-air (Not a valid use-case)	Use Evap	Use Evap	Use Ret-air (Evap is more useful)	Use Evap	Use Evap

NDT and Manual Defrost Config

Summary

The parameter **No Downwards Lockout Count** has been renamed to **NDT and Manual Defrost Config** to better reflect its improved functionality. The selectable value names have also been changed for the same reason. The changes are to:

- Allow it to operate fully and safely for electric and hot-gas defrost systems (previously had limited operation for safety reasons)
- Allow a limited number of higher frequency defrosts during evap freeze-ups
- Apply the same controls to Manual defrosts (which can also be a high frequency defrost when attempting to clear an evap freeze-up)

Full backwards compatibility has been maintained to ensure any FW upgrade, or use of any existing param files **maintains the same operation as currently exhibited**. This is to ensure approved and tested operation is never changed by updating FW.

New Parameter / Functionality		Pre-4020		4020 and above
No Downwards Lockout Count	**NDT and Manual Defrost Config**	**hot-gas or electric**	**passive**	
Disabled	Safety Temp	Blocked or Terminated on Temperature	Ignores termination temp	Ignores Termination Temp Terminates on Safety Temp (= 30degC termination temp by default)
0	Termination Temp	Blocked or Terminated on Temperature		Blocked or Terminated on Temperature
1-10	1-10	Blocked or Terminated on Temperature If attempted to trigger X times ABOVE termination temp, then does a system shutdown		Ignores termination temp Terminates on Safety Temp (= 30degC termination temp by default) If successfully triggers a NDT Defrost X times in a row, then does a system shutdown

Details

Disabled / Safety Temp	
Pre-4020 FW	For safety reasons, even when set to "disabled", the NDT Defrost was prevented from running when configured as a Hotgas or Electric defrost . This was to prevent any chance of a NDT defrost from being able to force a full defrost cycle (which actively injects heat into the system) when the temperature was already exceeding safe operating limits. This meant that the NDT Defrost capability had little benefit in any system except a Passive defrosting system.
New FW-4020 parameters / functionality	This safety issue has been resolved through the addition of a new parameter SAFETY TERMINATION TEMPERATURE. By default, this is set to the same 30degC as the DEFROST TERMINATION TEMPERATURE. This new parameter applies to ALL defrosts and operates on BOTH the Evaporator AND Return-air temperature. This allows a fundamental safety cut-out temperature to always be applied, thereby allowing a higher termination temperature during abnormal evap freeze-up conditions, and Passive, Electric and Hot-gas defrosts to all be treated the same The name **Safety Temp** has therefore been used, as that is the only temperature that can terminate a NDT Defrost Likewise, the option 0 has been renamed **Termination Temp**, as that is the option that allows the NDT Defrost to be terminated by the Defrost Termination Temperature. This is functionally no different to pre-4020 FW.

Values between 1-10	
Pre-4020 FW	Setting NO DOWNWARDS TENDENCY LOCKOUT COUNT to a value of 1-10 was intended to provide a means of identifying unrecoverable freeze-ups (or any other failure to reduce temperature) to shut the system down. However, it operated as per selection "0" and was configured to BLOCK the NDT Defrost. It was therefore simply counting how often you were NOT allowing a NDT defrost recovery to occur before shutting down. This had minimal value and was therefore not being used.
New FW- 4020 parameters / functionality	A more valuable approach is to ALLOW a NDT Defrost to occur (which will actively assist in clearing an evap freeze-up), and then count how many of them HAVE occurred. If after X attempts to clear a frozen evap it has not resolved the issue, THEN you shutdown. This is possible due to the addition of the "Defrost Safety Termination temperature" ensuring safety is not compromised. To complement this change, there is now also: • The ability to set the NDT Defrost differential which triggers the NDT Defrost • A resolution increase on the NDT Defrost Time to 6min increments to allow NDT Defrost to be configured at a HIGHER rate than a timed defrost • Fundamentally, the Timed defrost has failed to prevent the evap freeze-up, so this allows the NDT Defrost to be potentially configured as a temporary higher frequency defrost schedule while a freeze-up is detected.

Manual Defrosts

Manual defrosts have now been brought under the same defrost termination logic as a NDT Defrost. This is because a manual defrost is an on-demand defrost that typically only occurs when a freeze-up has been identified. Just like a NDT Defrost, multiple Manual defrosts may be needed in quick succession to resolve a freeze-up, but safety must still be maintained.

Maintaining operation when writing existing parameter files or a FW update

If a parameter file generated using pre-4020 FW (a Revision 1 file) is written to FW-4020 or above, OR the FW is upgraded from pre 4020 to FW-4020 or above, THEN, the following transformation is applied to maintain the same defrost termination functionality as on pre-4020 FW

pre-4020 parameters		When written to 40210 OR when FW upgraded from pre-4020	
Defrost Type	**No Downwards Tendency Lockout Count**	**NDT and Manual Defrost Config**	**Safety Termination Temperature**
Hot-gas or Electric	Disabled	Set to 0 Blocked or Terminated on Temperature	Default to 30
	0		
	0-10		
Passive	Disabled	Disabled Ignores Termination Temp	Default to 30
	0	Set to 0 Ignores Termination Temp	
	0-10		

If a parameter file generated from the 4020 FW (a Revision 2 file) is written to FW-4020, no transformation is applied.

Default parameter file for backwards compatibility

AoFrio has maintained the default parameters for 15xx, 161x, 162x, 163x with the FW-4020 update except for two exceptions. This means that any parameter file created after the FW-4020 update will work on the Field, Lab and Cradle app when used on OLD_SCS hardware except for

- ADx NTC Type (where x is 1-5)

- Minimum Displayable Temperature (when used on 15xx or 161x)

Please speak to your AoFrio representative to assist in finding a resolution for these two exceptions.

Improved NTC Type support

The FW-4020 update supports an improved NTC Type, 'Type 0', which uses a table mapping for the AoFrio NTC instead of the more generic Beta and Resistance formulaic approach. This provides greater temperature accuracy when used at very low temperatures. By default, 4020 uses ADx NTC Type = 0.

Please note - if you are setting an **ADx NTC Type parameter** to 0 on a device through the Lab or Field app without making the FW-4020 update, it will write all parameters except these ones and flag them as "Not loaded due to invalid values". This means the ADx NTC Type won't be modified by the parameter file and the FW will function as expected.

Change log

Firmware variant	Date released	Description
4000	Early 2022	• Supports series 15XX firmware functionality on new SCS micro
4001	Late 2022	• Minor Bug fixes
4010	Feb 2023	• Supports series 16XX firmware functionality on new SCS micro • Parameter name changes[1]
4020	Feb 2024	• Minor Bug fixes • Supports series 15 XX and 16XX firmware functionality on the new and old SCS micro • Supports Install type on all.