DULAS Solar Direct Drive
Fault finding and repair manual

Table of Contents

1. SAFETY INSTRUCTIONS 3

2. WHO IS THIS GUIDE FOR? 5

3. REFRIGERATOR COMPONENTS 6

4. MATERIAL SAFETY INFORMATION 9

5. END OF LIFE & PRODUCT RECYCLING 10

6. WHICH CHECKS DO I NEED TO PERFORM? 11

7. THE DULAS SDD CONTROLLER 13

8. SCHEMATICS OF DULAS SDD CONTROLLER 14

9. CHECKING THE DULAS SDD CONTROLLER 16

10. CHECKING THE THERMOSTAT ACCURACY 18

11. CHECKING THE USB VACCINE GUARD CHARGING OUTPUT 18

12. CHECKING THE CAPACITOR 19

13. CHECKING THE TEMPERATURE SENSORS 20

14. CHECKING PV ARRAY AND CABLES 21

15. CHECKING THE COMBINED PV ISOLATOR AND CIRCUIT BREAKER 25

16. CHECKING MOVS ON REFRIGERATORS WITHOUT A LIGHTNING PROTECTION CIRCUIT BOARD 26

17. CHECKING THE LIGHTNING PROTECTION BOARD (IF FITTED) 27

18. CHECKING THE COMPRESSOR CONTROLLER 28

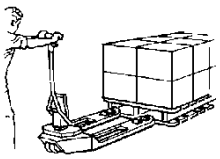
19. CHECKING THE COMPRESSOR 29

20. CHECKING THE REFRIGERATION CIRCUIT 30

21. VC60SDD-1 AND VC150SDD FREEZER SWITCH REPLACEMENT 31

1. Safety Instructions

Read the Manual - please read all instructions completely before carrying out any repair work. System servicing should only be carried out by a qualified and competent engineer. Work performed by persons with insufficient technical knowledge may adversely affect the performance of the unit or cause physical injury or damage to the equipment.



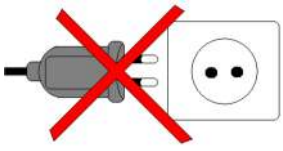
Refrigerator and power system are heavy - please observe good manual handling procedures when moving the refrigerator or solar power system. Only use suitable transport equipment.

Safe working - Please observe safe working at height practices when working on the solar array.

Live electrical components – solar modules are live when exposed to sunlight. Isolate the array (using the PV isolator on the back of the refrigerator) before disconnecting any components.

Electrical danger – when charged the capacitor can provide short periods of VERY high current. Take care not to accidentally short the capacitor terminals. The capacitor must be allowed to discharge before beginning work on the system.

Electrical danger – under fault conditions high electrical currents can occur. Never bypass a circuit breaker and always replace with the same type and rating.



DC power only - this refrigerator is designed for operation with the solar power system supplied. Do not connect the refrigerator to other power supplies.

Dangerous substances - this refrigerator contains substances that are not biodegradable and can cause harm, please ensure that all components of the refrigerator are disposed of correctly, see Sections 4 & 5 for more information. Do not damage the internal side panels of the compartment.

	**Keep Dry –** This refrigerator is for indoor use only. Do not expose it to rain.

WARNING: This unit's cooling system contains flammable refrigerant. Due to this fact, the following information is particularly important:

	**Warning:** Do not damage the refrigeration circuit. Ensure that sharp or pointed objects do not come into contact with the refrigeration circuit. **Warning:** Do not use mechanical devices or other means to accelerate the defrosting process, other than those recommended by the manufacturer.
	**Warning:** Keep ventilation openings, in the appliance enclosure or in the built-in structure, clear of obstruction. **Warning:** Do not use electrical equipment inside the appliance. **Warning:** Do not store explosive substances such as aerosol cans with a flammable propellant inside this appliance.
	**Warning:** Do not use open fire or electrical tools near R600a refrigerant R600a. The service personnel must be specially trained for the handling of flammable refrigerants. This implies knowledge of tools, transport of compressors and refrigerant as well as all relevant rules and safety regulations.

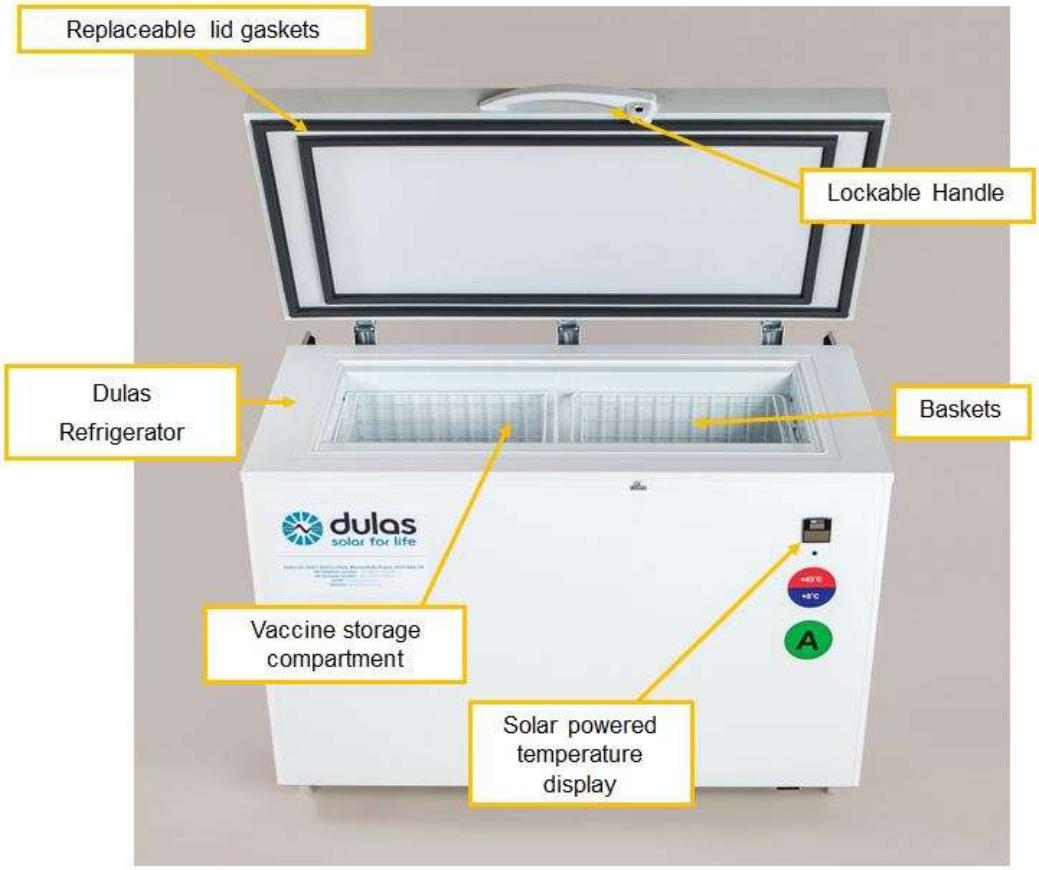
2. Who is this guide for?

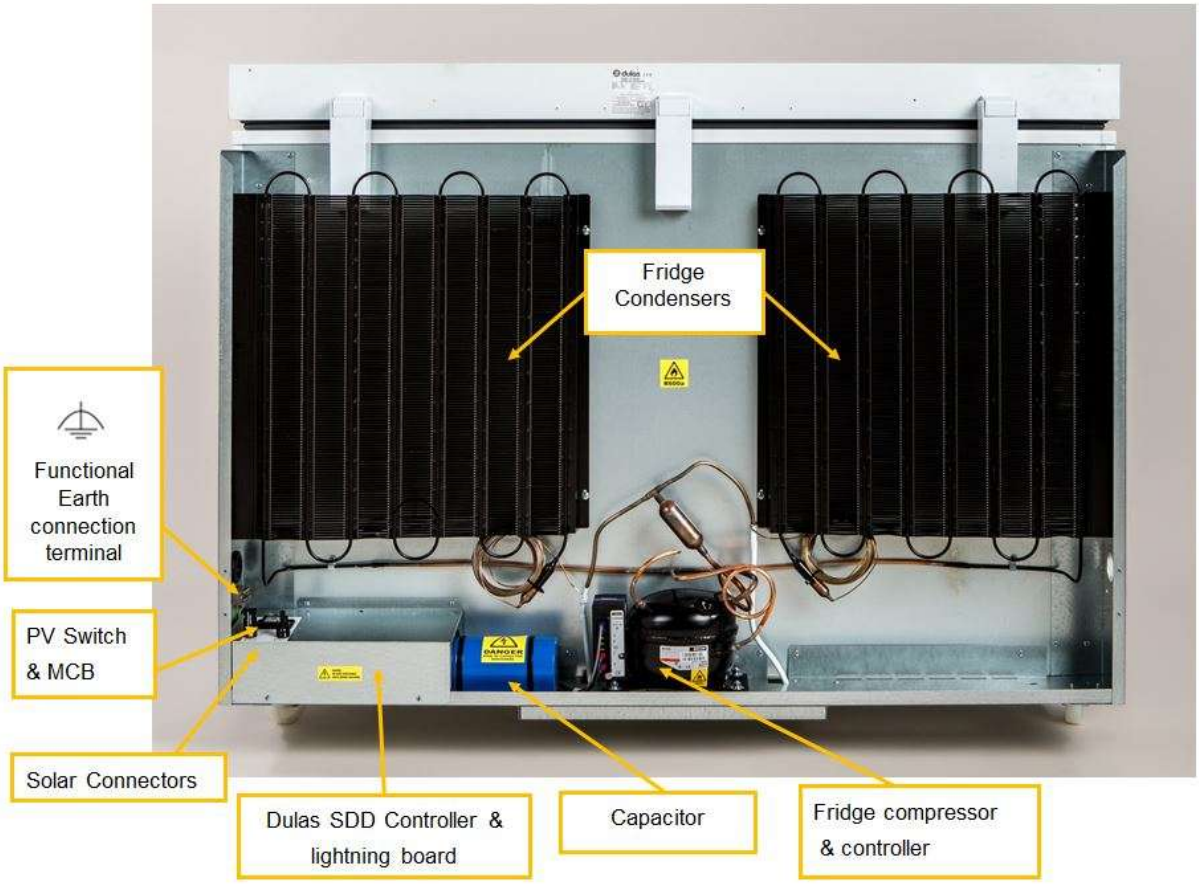
This guide is for experienced technicians. It assumes:

- The technician will have a basic knowledge of electricity and be able to make safe, reliable connections.
- The technician will be familiar with basic test equipment such as clamp meters and multimeters and will be able to obtain accurate results.
- The technician will be able to find the right screws to remove covers and fixings and they will be replaced at the end of the test.
- If wiring or settings are temporarily altered to perform tests notes will be taken of the original configurations and the equipment will be restored to the original condition at the end of the test.
- The technician will be able to make clear records of the test results and the work that has been carried out.

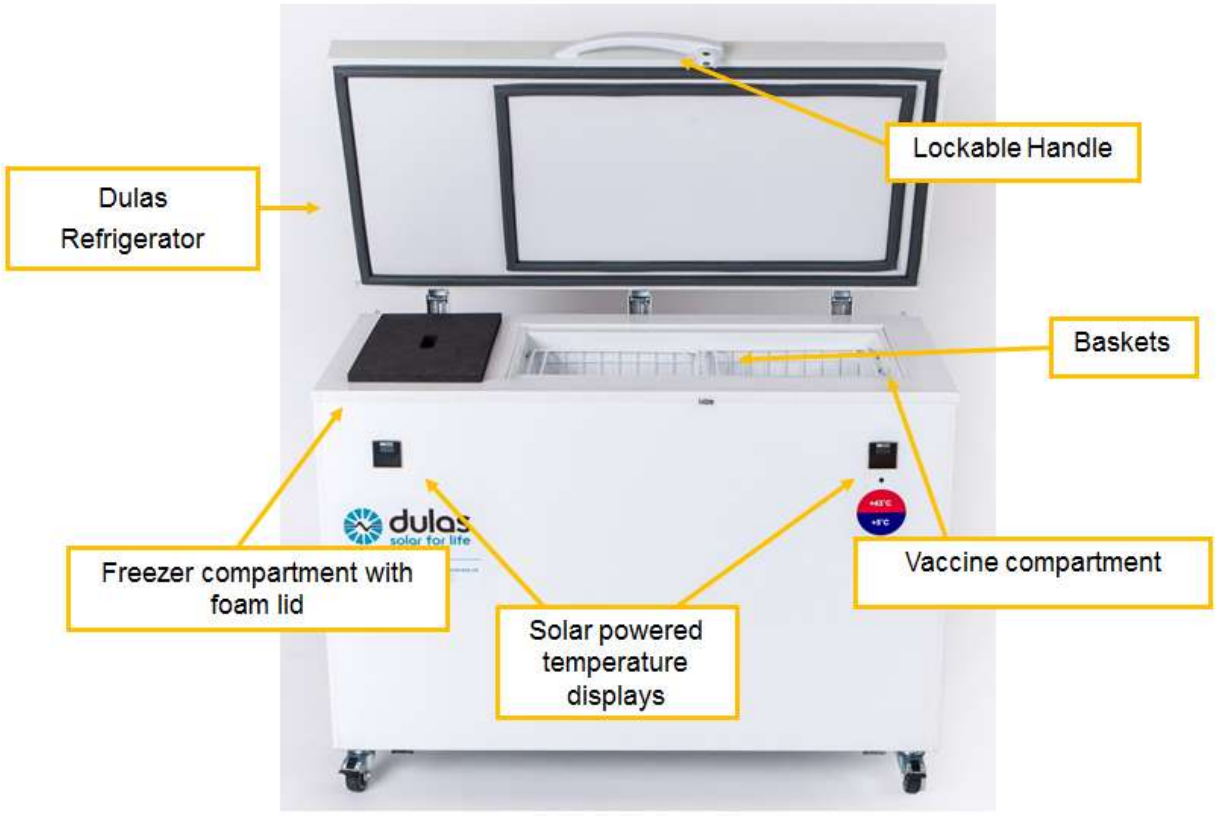
3. Refrigerator Components

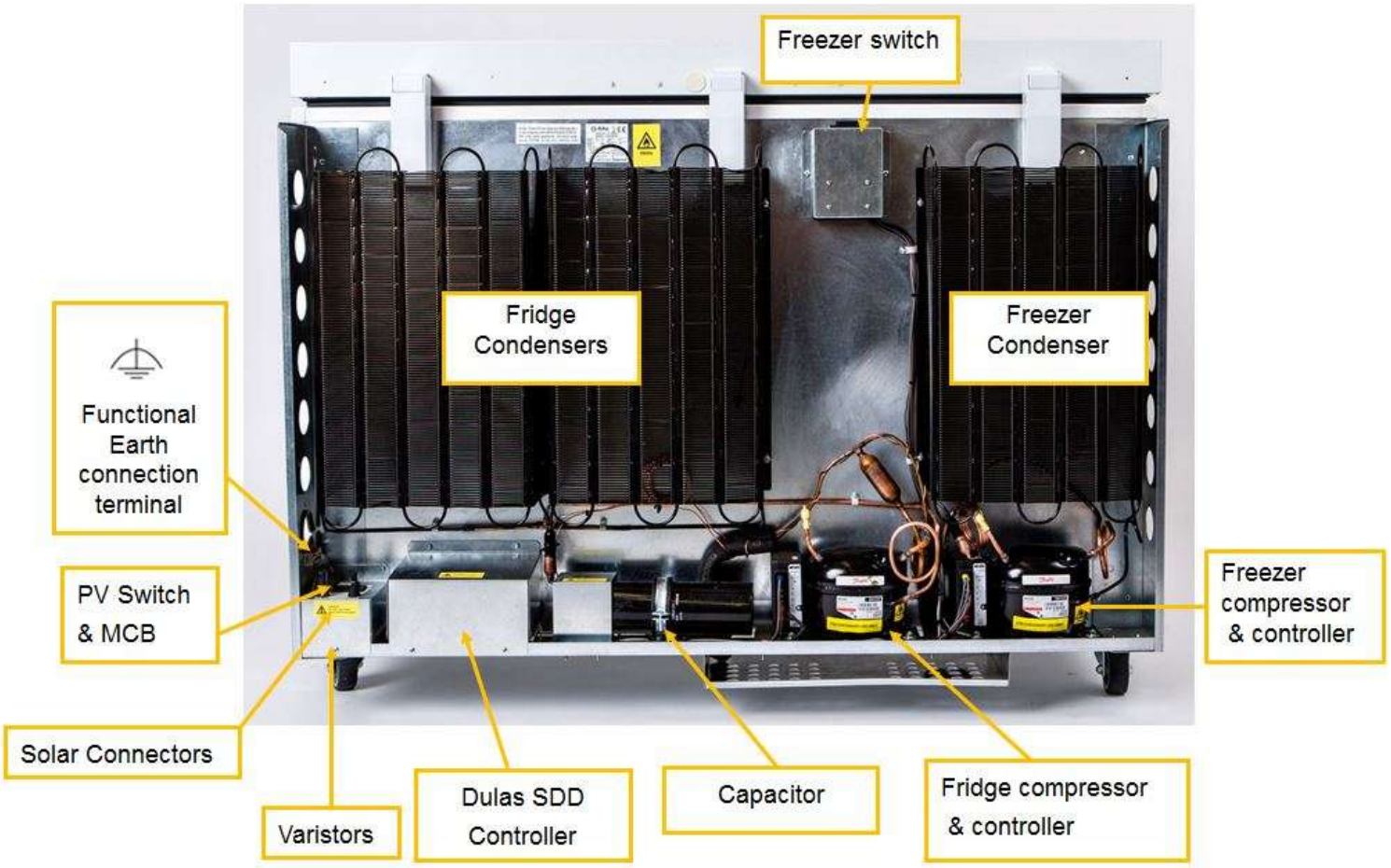
Dulas VC200SDD / VC110SDD / VC88SDD



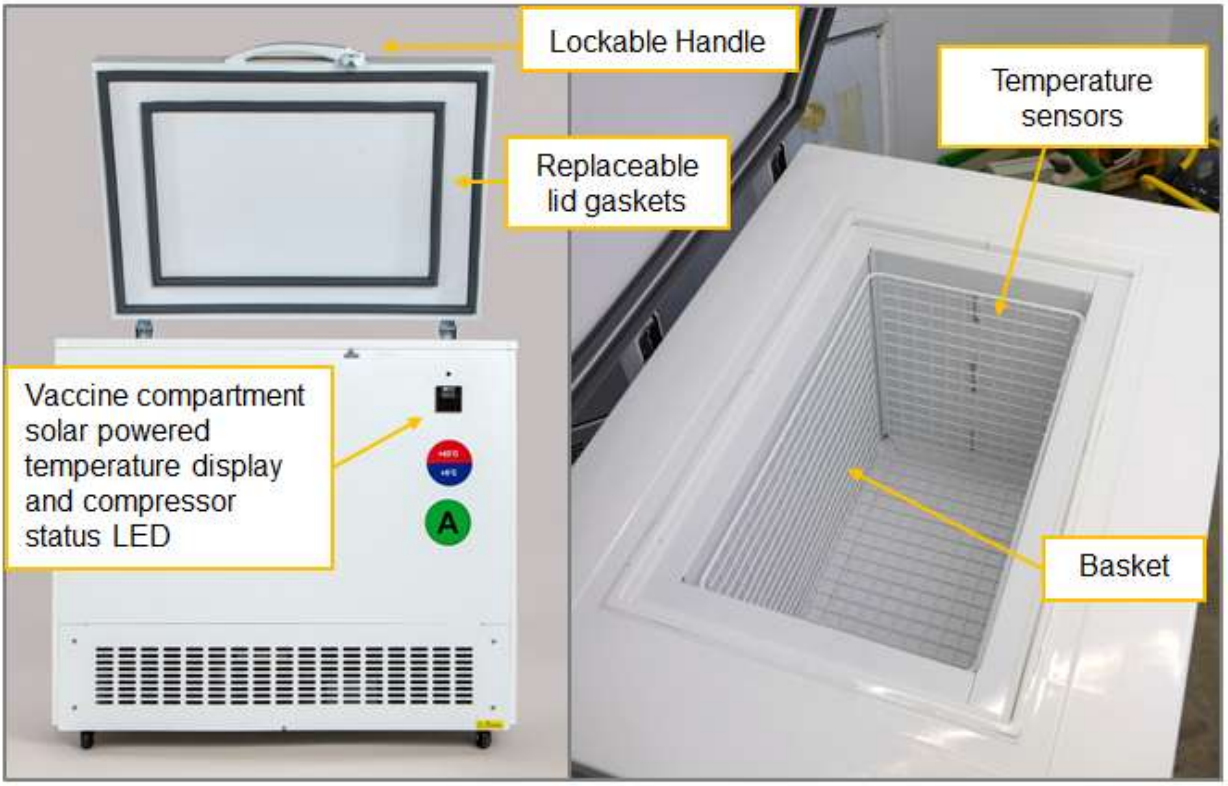


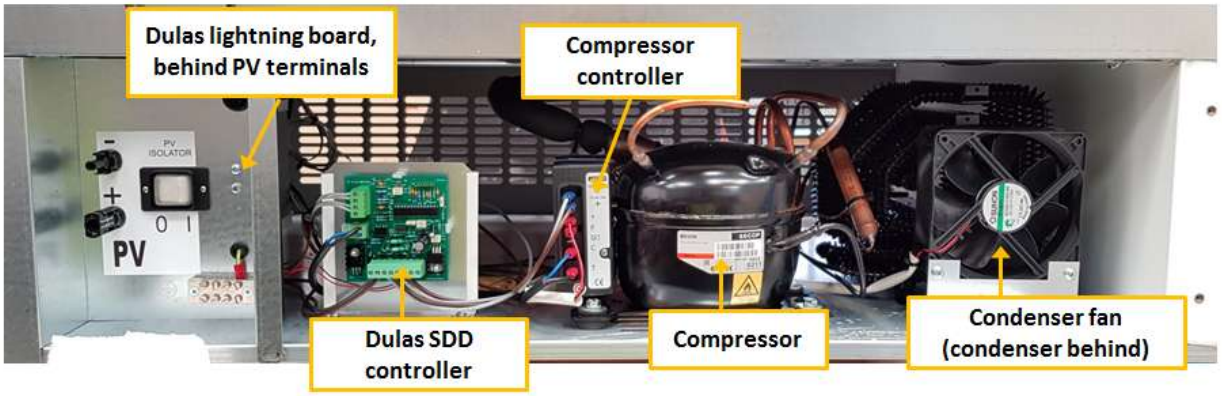
Dulas VC60SDD-1 / VC150SDD

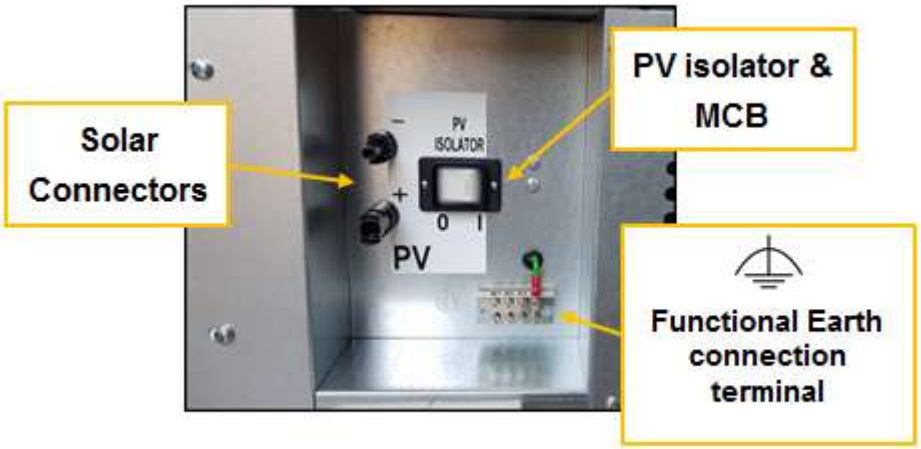




Dulas VC30SDD / VC50SDD







4. Material Safety Information

THE REFRIGERATOR

Dulas SDD refrigerators conform to the European directive 2002/95/EC on hazardous substances and do not contain the following elements: lead, cadmium, mercury, hexavalent chrome, PBB or PBDE.

The absence of ozone destroying materials is in accordance with EC 1005/2009 (CFC-free)

They are compliant with European Standards (CE) EN60335-1:2010 & EN60335-2-24:2010.

R600a refrigerant – Isobutane, is highly flammable when mixed with air. Do not inhale, ingest, and avoid contact to skin. Ensure that any work carried out on the refrigeration circuit is done by a competent refrigeration engineer who has been trained to work on flammable refrigerants.

THE PHASE CHANGE MATERIAL (PCM)

Dulas SDD refrigerators contain an organic phase change material (PCM) that provides the energy store for the refrigerator. This PCM material is a paraffin wax that is liquid at room temperature and is stored in large tanks secured inside the walls of the refrigerator. In normal use the user will never be aware of its presence. This PCM is classified under regulation (EC) No 1272/2008 as a category 1 aspiration hazard and is classified under regulation 67/548/EWG, 1999/45/EG as having the potential to cause physical harm (R65 & R66). At normal ambient temperatures this product will be unlikely to present an inhalation hazard because of its low volatility. At high temperature aerosol/mist can cause an irritation of the respiratory tract.

H304 May be fatal if swallowed and enters airways.

P301 + P310 IF SWALLOWED: Immediately call a POISON CENTRE or physician.

P331 DO NOT induce vomiting.

R65: Harmful: may cause lung damage if swallowed.

R65: Repeated exposure may cause skin dryness or cracking.

In the event of a PCM spillage:

- Wear suitable protective clothing, gloves and safety glasses when clearing up spillages.
- Use an absorbent substance such as sand to contain any escaping material.
- Do not allow to enter drains / surface waters / groundwater. In case of the leakage of a large amount inform the responsible authorities.

5. End of Life & Product Recycling

WORN OUT REFRIGERATOR

The refrigerator still contains valuable materials and is not to be disposed of in the normal household waste.

- Ensure that the cooling circuit of the worn out device is not damaged when being transported.
- Information on the coolant used is on the type plate on the back of the refrigerator.
- The walls of the refrigerator contain an organic phase change material that can be harmful and must be disposed of safely. Please contact Dulas for advice.
- Worn out devices must be professionally disposed of in accordance with local regulations and legislation.

Potentially hazardous components / materials are:

- Refrigerant gas (R600a)
- Phase change material (PCM) - paraffins, normal C5-20
- Electrolytic capacitor
- Electronic components:
  - SDD controller
  - Compressor controller
  - Refrigerator compartment temperature display

Disposal of Phase Change Material (PCM)

The PCM used in the Dulas refrigerator has a very long life and does not degrade through use. At the end of the refrigerators useful life the PCM should be either recycled or disposed of in accordance with applicable regional, national and local laws and regulations. Contact your local waste disposal authority for advice. The product can be incinerated in accordance with local regulations. In the EU it has a Waste Disposal Code (EWC): *13 08 99 oil waste not otherwise specified.*

SOLAR POWER SUPPLY

Do not dispose of this equipment with normal domestic waste!

To comply with the European Directive 2002/96/EC on Waste Electrical and Electronic Equipment and its implementation as national law, electrical equipment that has reached the end of its life must be collected separately and returned to an approved recycling facility. Any device that you no longer require must be returned to our agent, or find out about the approved collection and recycling facilities in your area.

Ignoring this European Directive may have potentially adverse effects on the environment and your health!

Solar modules contain materials that can be recovered and reused in either new PV modules or other new products. Industrial recycling processes exist for both thin-film and silicon modules. Materials such as glass, aluminium, as well as a variety of semiconductor materials, are valuable when recovered.

6. Which checks do I need to perform?

Before a doctor can find out what is wrong with a patient they ask the patient questions and find out the symptoms. Then the doctor can work out what tests need to be done to find the right diagnosis. The same is true with SDD refrigerators. We must ask the right questions before we start testing. There are four basic symptoms:

1. **The refrigerator is always too cold**
   - So we know that the compressor is working and that there is enough power to make sure the refrigerator is always cold.

2. **The refrigerator is sometimes too warm and sometimes at the correct temperature**
   - So we know the refrigerator is working, but something is preventing it cooling enough. This is most likely to be an issue with the PV array.

3. **The refrigerator is always too warm and the compressor never runs**
   - As the compressor never runs the problem is likely to be that power is not getting to the compressor.

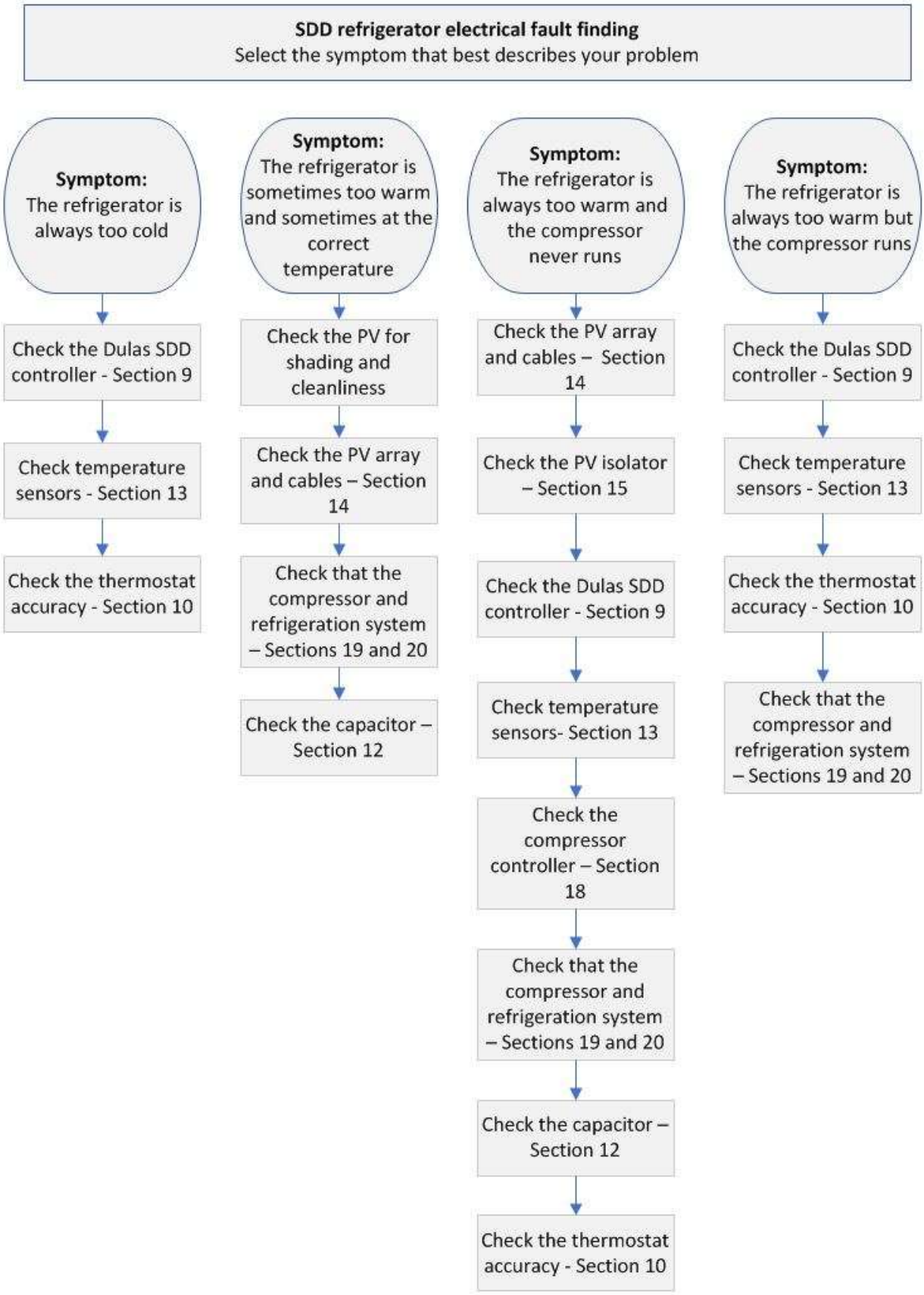
4. **The refrigerator is always too warm but the compressor runs**
   - As the compressor runs this means we have no problem with the power supply. It is most likely this symptom will be the result of a refrigerant gas leak.

Once we have worked out which situation we have we can do the right tests to find where the fault is. The chart on the following page shows which tests should be performed and where you will find the test procedure in this guide.

In addition to these points there are two other areas that need to be considered:

1. **Lightning protection.** The lightning protection systems can prevent failure of the refrigerator caused by electrical storm activity but may be degraded over a period of time. In areas of frequent lightning storms the lighting protection circuits will need periodical checking even though the system may be working normally. If fault finding or repair work is carried out on the refrigerator it is advisable that the lightning protection systems are checked at the same time. See Sections 16 and 17.

2. **Vaccine Guard failure.** Some Dulas vaccine refrigerators are fitted with the “Vaccine Guard” remote temperature monitoring system. If you are experiencing problems with the Vaccine Guard you should check that it is being properly charged. The procedure for checking that the USB charging socket is working correctly can be found in Section 11.


SDD refrigerator electrical fault finding
Select the symptom that best describes your problem
Symptom: The refrigerator is always too cold
Check the Dulas SDD controller - Section 9
Check temperature sensors - Section 13
Check the thermostat accuracy - Section 10
Symptom: The refrigerator is sometimes too warm and sometimes at the correct temperature
Check the PV for shading and cleanliness
Check the PV array and cables – Section 14
Check that the compressor and refrigeration system – Sections 19 and 20
Check the capacitor – Section 12
Symptom: The refrigerator is always too warm and the compressor never runs
Check the PV array and cables – Section 14
Check the PV isolator – Section 15
Check the Dulas SDD controller - Section 9
Check temperature sensors- Section 13
Check the compressor controller – Section 18
Check that the compressor and refrigeration system – Sections 19 and 20
Check the capacitor – Section 12
Check the thermostat accuracy - Section 10
Symptom: The refrigerator is always too warm but the compressor runs
Check the Dulas SDD controller - Section 9
Check temperature sensors - Section 13
Check the thermostat accuracy - Section 10
Check that the compressor and refrigeration system – Sections 19 and 20

7. The Dulas SDD controller

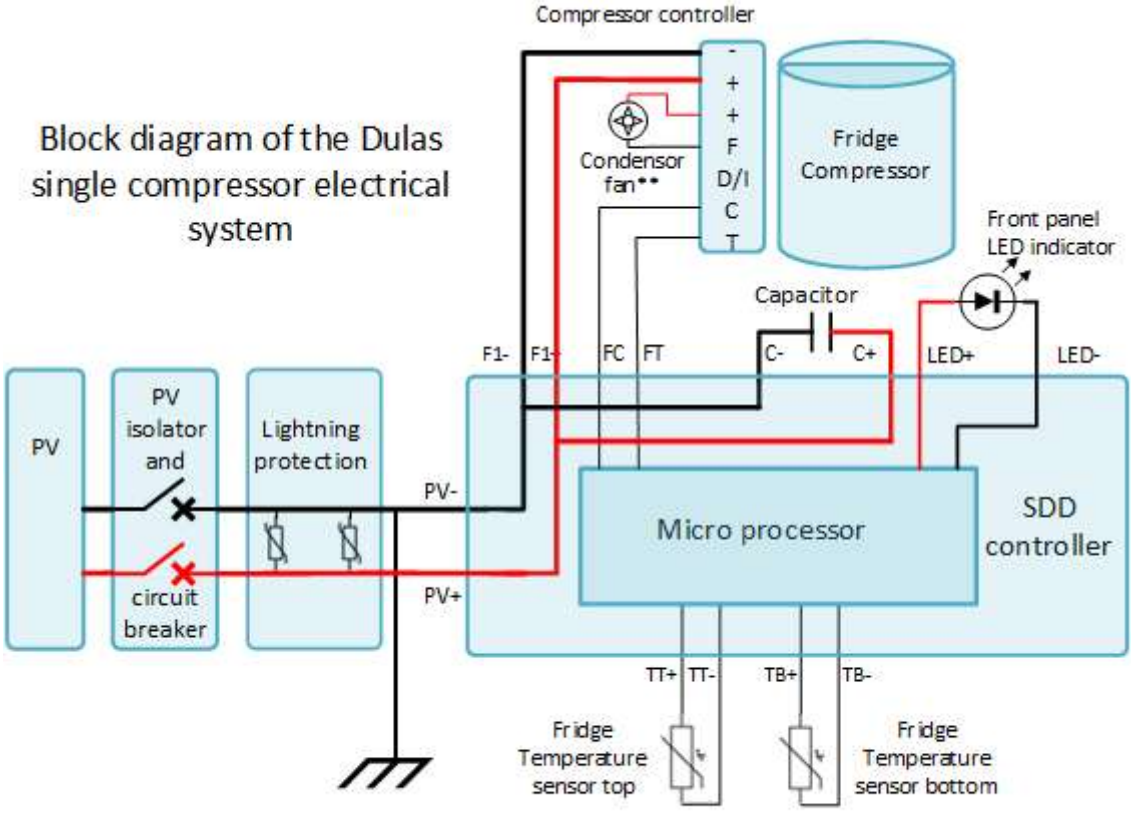
General description

You will find several variants of the SDD controller on Dulas SDD refrigerators. They all perform the same basic functions and can be tested in a similar way; refer to Section 8 for an overview of the various types.

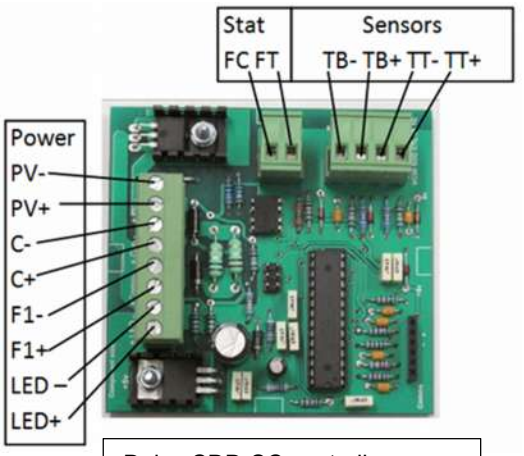
The Dulas SDD controller does the following:

- It provides a pathway for the power from the PV to flow to the compressor controller(s), capacitor and compressor(s).
- It controls the speed of the compressor to match the amount of power coming from the PV.
- It senses the temperature in the refrigerator (and freezer) compartments and switches the compressor on and off to maintain the correct temperature.
- It turns on the light at the front of the refrigerator when the refrigerator compressor is running.
- On certain models the controller also provides charging for the Vaccine Guard remote temperature monitoring and control and power for the Dulas Solar Socket energy harvester.

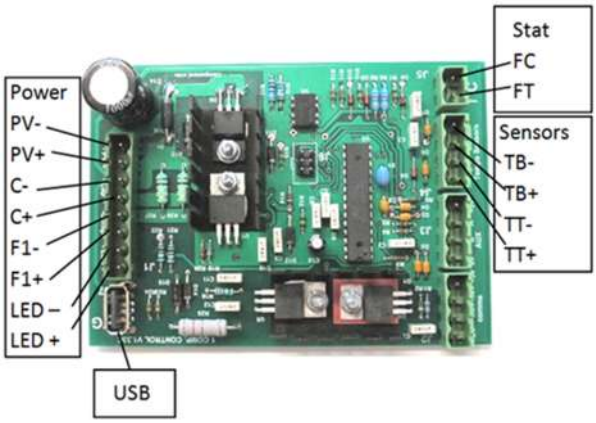
8. Schematics of Dulas SDD controller



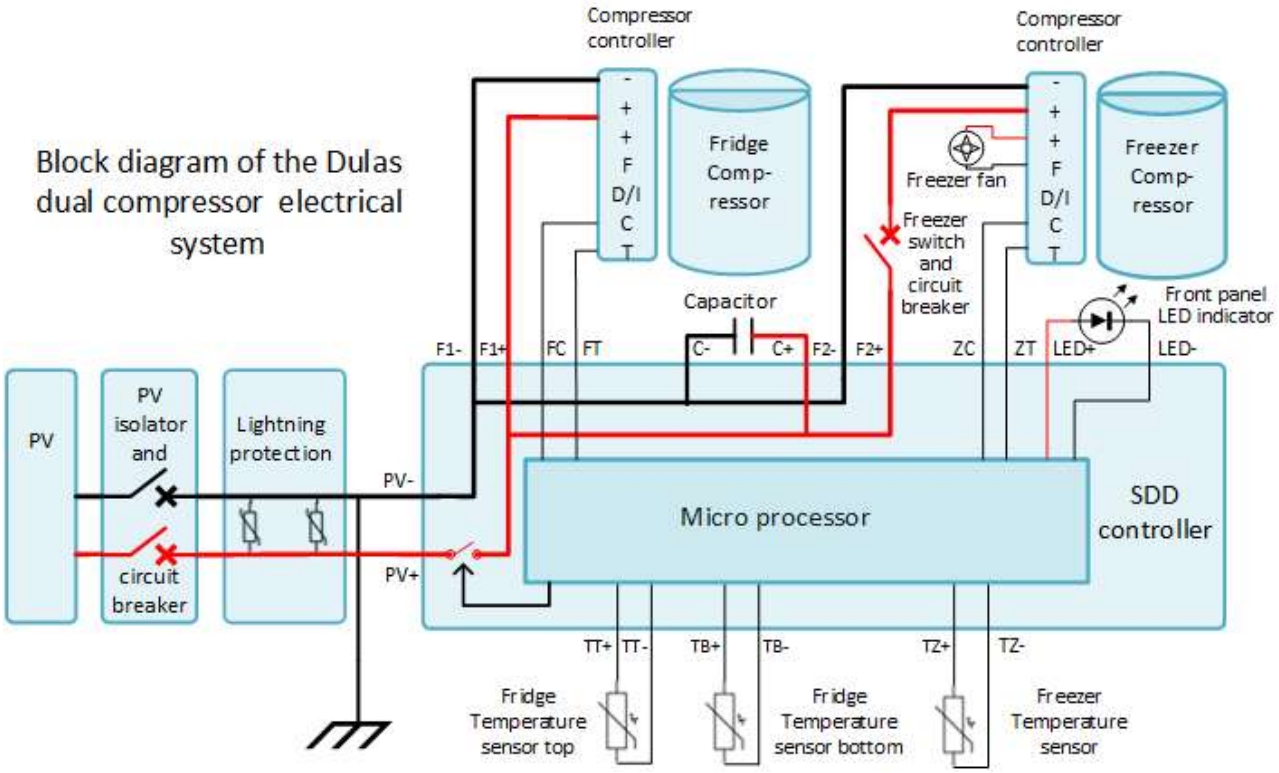
** Condenser fan not fitted on all models

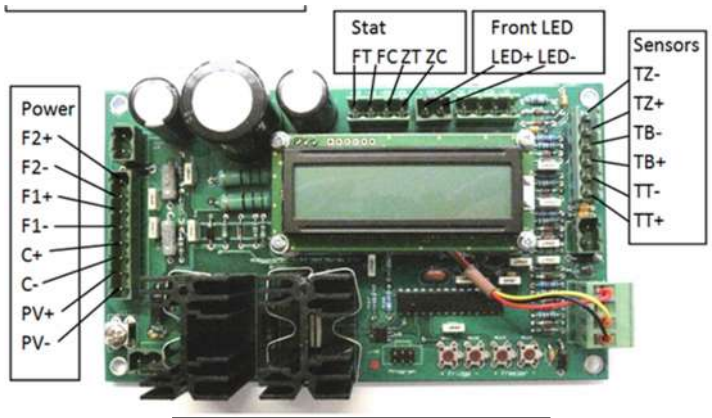


Dulas SDD-SC controller
Version:
Cabinets:
Standard fit to all single compressor cabinets from April 2017.

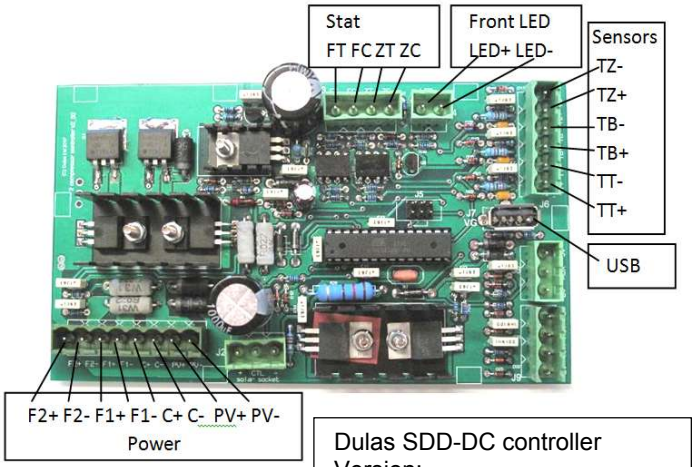


Dulas SDD-SC controller
Version:
Cabinets:
Standard fit to all Vaccine Guard enabled single compressor cabinets from February 2018

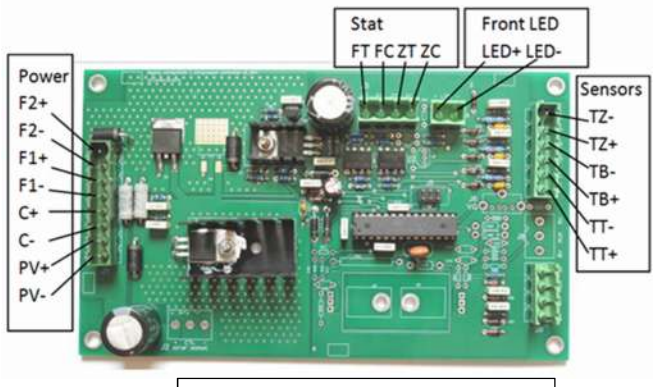




Dulas SDD-DC controller
Version:
Cabinets:
Standard fit to VC150SDD until December 2016



Dulas SDD-DC controller
Version:
Cabinets:
Standard fit from: ___ to ___



Dulas SDD-DC controller
Version:
Cabinets:
Standard fit from: ___ to ___

9. Checking the Dulas SDD controller

Refer to Section 8 for connection identifications for your particular SDD controller

Before testing the controller:

- Switch the PV isolator to “0” to disconnect the PV array. Remove the controller cover or panels to gain access to the SDD controller.

- Inspect the SDD controller: check that
    a. The board is clean, undamaged, and dry.
    b. That the connection screw terminals are tight and the connectors are pushed fully into their sockets on the circuit board.

  If the board shows signs of corrosion or damage it should be replaced. The source of the problem should be identified and corrected before continuing.

- Ensure that there is sufficient sunlight to power the compressor(s). A PV array Isc (short circuit current) of more than 2A is required to start run a single compressor refrigerator and a PV array Isc of more than 5A is required to start a dual compressor refrigerator-freezer. Refer to Section 14 for guidance on measuring the Isc.

- Re-connect the PV array to the refrigerator and switch the PV isolator to “1” to connect the PV.

Test no	Test	What to do if the test fails
1	**Simulate a high refrigerator temperature:** Remove the sensors connector and temporarily link the TT+ and TT- terminals and the TB+ and TB- terminals. The refrigerator compressor should now run.	If the compressor does not run go to test 5 to check the wiring.
2	**Simulate a low refrigerator temperature:** Unplug the sensors terminal block so that the temperature sensing inputs are open circuit. The compressor should stop working.	If the compressor runs whilst the sensor inputs are disconnected there is a possibility that the fault lies with the stat cabling or compressor controller; disconnect the stat connector and check that the compressor stops. If it does stop the SDD controller is faulty and needs replacing.
3	**For a dual compressor refrigerator-freezer only – repeat tests 1 & 2 for the freezer:** Remove the connections to the TT+, TT-, TB+ and TB- terminals and temporarily link the TZ+ and TZ- terminals. This will simulate a high freezer temperature and the freezer compressor should now run.	If the compressor does not run go to test 5 to check wiring.

4	**For a dual compressor refrigerator – freezer only.** The compressor should stop when the links between TZ+ and TZ- are removed and the terminals are open circuit.	If the compressor runs whilst the sensor inputs are open circuit, disconnect the ZT and ZC connections and check that the compressor stops. If it does stop the SDD controller is faulty and needs replacing.
5	If test 1 (and 3 if required) is not successful check that the voltage between PV- and PV+ is between 25 and 38V.	Check the wiring from the PV input terminals to the SDD controller.
6	Check that the voltage between F1+ and F1- is the same or slightly less than the voltage measured in test 5.	The SDD controller is damaged and should be replaced.
7	Check that there is the same voltage as measured in test 6 at the + and – terminals on the SDD controller.	Check wiring between the SDD controller and the compressor controller.

10. Checking the thermostat accuracy

The thermostat in the SDD controllers is set to 3.7C. The accuracy of the thermostat can be checked by temporarily replacing the temperature sensors with resistors:

Resistor value for top sensor (between TT+ and TT-)	**Resistor value for bottom sensor (between TB+ and TB-) not required for VC30SDD**	**Resistor value for freezer sensor (between TZ+ and TZ-). Refrigerator freezers only**	**Expected result**
24k 1% (equivalent to 3.0C)	24k 1% (equivalent to 3.0C)	Open circuit	Refrigerator compressor stopped.
22k 1% (equivalent to 5.1C)	22k 1% (equivalent to 5.1C)	Open circuit	Refrigerator compressor running.
Open circuit	Open circuit	75k 1% (equivalent to -21.2C)	Freezer compressor stopped.
Open circuit	Open circuit	56k 1% (equivalent to -15.5C)	Freezer compressor running.

11. Checking the USB Vaccine Guard charging output

The USB socket on the SDD controller provides current to charge the Vaccine Guard internal battery. Without charging the Vaccine Guard battery will power the unit for 100 days.

Check that the Vaccine Guard unit is connected to the USB socket on the SDD controller.

- If the USB socket is providing current the 3 lights are on 100% of the time.
- The “Battery” light (bottom one) is red until the battery is fully charged. When the battery is fully charged it will turn green.

- If no charging current is present the lights flash very briefly every 5 seconds. This is normal when there is no power from the PV array.
- During the day, if the PV is connected to the refrigerator and the USB cable to the Vaccine Guard is connected, the 3 lights should be on permanently.

12. Checking the Capacitor

The capacitor provides a short term energy store that helps to start the compressor and also helps to keep the compressor running during short periods of low sunlight. The capacitor has a design life of 20 years and should not fail during the life of the refrigerator, however if you suspect it has developed an issue the following test can be used to verify its performance.

WARNING when charged the capacitor can provide short periods of VERY high current, high enough to create local melting of tools. Take care not to accidentally short the capacitor terminals.

To help protect against this risk there is a 2.7 kilo ohm resistor connected directly across the terminals to provide a discharge path for the capacitor if the PV isolator is switched off. This takes approximately 2 minute to discharge the capacitor.

To test the capacitor:

Test No	Test
1	Switch the PV isolator to “0”. Disconnect the sensors terminal block to prevent the compressors running.
2	If a “Vaccine Guard” is fitted to the refrigerator disconnect the USB cable that connects it to the refrigerator.
3	Switch the PV isolator to “1” and measure the voltage at the C+ and C- terminals. When it has stabilised, switch the PV isolator to “0” and immediately unplug the power terminal block.
4	Measure the voltage between the C+ and C- terminals and time how long it takes for the voltage to reduce to 10V. The time taken will depend on the capacitor value but should be at least as long as indicated in the table below.
5	Remember to re-connect the “Vaccine Guard” cable and circuit board power connector, and replace external covers when you have finished.

Capacitor value	Minimum time for the capacitor voltage to reach 10V.
47,000uF (0.047F)	2 minutes
100,000uF (0.1F)	4 minutes
150,000uF (0.15F)	6 minutes

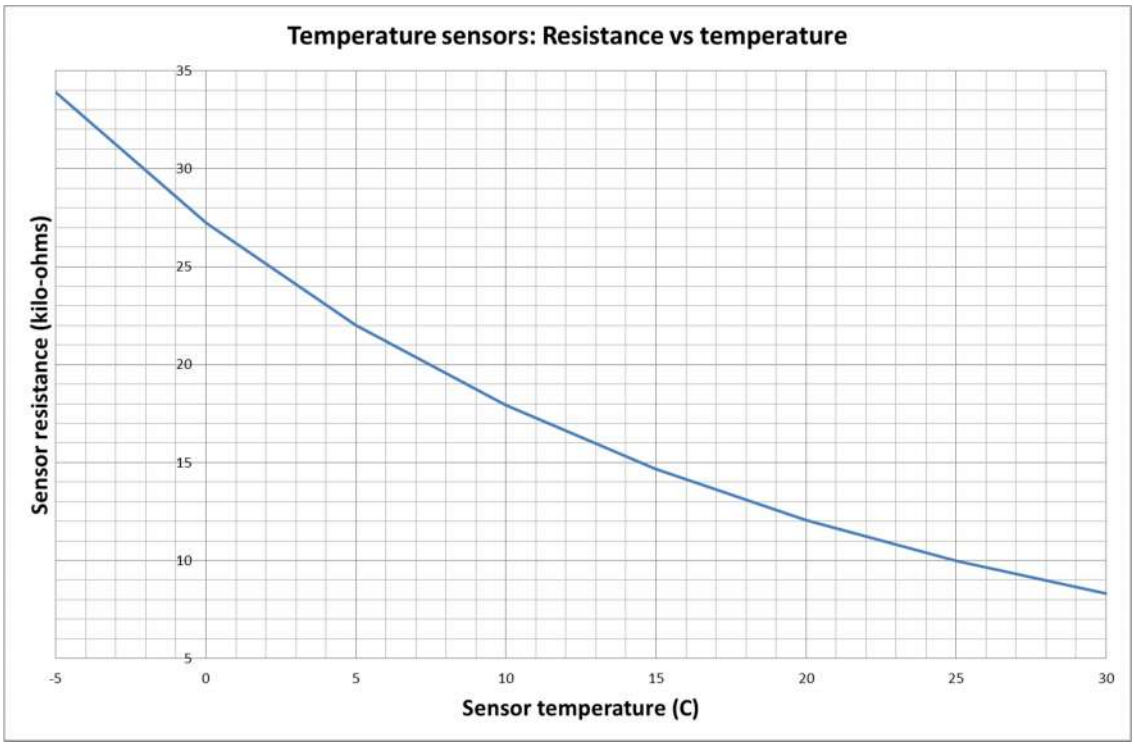
If the discharge time is less than the values indicated the capacitor may be degrading and should be replaced.

13. Checking the temperature sensors

The temperature sensors in the Dulas SDD are Negative Temperature Coefficient (NTC) thermistors, their electrical resistance decreases with increasing temperature. They are hermetically sealed and very reliable.

To check that they are working correctly, unplug the *sensors* terminal block from the SDD controller and measure the resistance between the appropriate terminals with a multimeter. *Note: it is important that the tester's hands are not touching the exposed multimeter probes or sensor wired as this can affect the measured values.* Use the following table and graph to check that the resistance is in line with your estimation of the correct sensor temperature.

Sensor temperature (C)	Sensor resistance (kΩ)
-25	87.6
-20	68.2
-15	53.7
-10	42.5
-5	33.9
0	27.2
5	22.0
10	17.9
15	14.7
20	12.1
25	10.0
30	8.3
35	6.9
40	5.8
45	4.9



14. Checking PV array and cables

Step 1 - Check the condition of the PV cable and connectors

1. Check that ***all*** the PV connectors from the array to the refrigerator are dry and protected from direct rain and sunlight.
2. Check that all mating connectors are **fully** pushed together.
3. Check that the PV cable insulation is not degrading where it is exposed to direct sunlight.
4. Check that the PV cable insulation is protected and has not been damaged where it comes into contact with rough or sharp objects such as the edge of a steel roof.

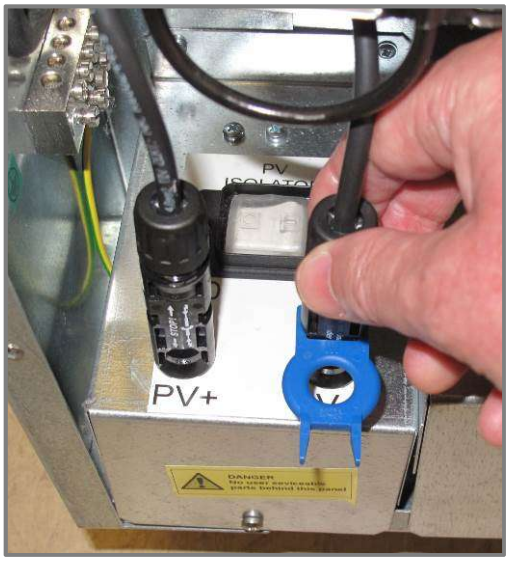
Step 2 - Checking the output voltage and current of the PV array

For this test you will need:

- A separate cloth or sheet of cardboard that will completely cover each module and doesn't let the light through. A thick dark blanket would be suitable.
- A DC clamp meter.
- A multimeter or voltmeter.
- An MC4 connector release tool for separating PV connections.

Setting up:

- Check that the modules are all completely free from shading and are clean.
- Switch the PV isolator switch to "0".
- Disconnect the PV cables from the refrigerator using the release tool.



To measure the open circuit Voltage (Voc)

- Use a multimeter set to DC volts.
- For the 60 cell modules used with Dulas SDD refrigerators the open circuit voltage should be between 30 and 40V. Refer to the solar panel data sticker for the exact value.

Voc →

To measure the Short circuit current (Isc):

- Connect the PV cables together.
- Use a DC current clamp meter to measure the current.

Remember to “zero” it before clamping around the cable.

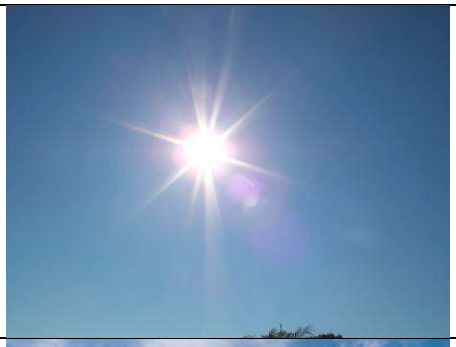
- When you have finished taking all the current measurements the PV cables can be disconnected.

Cover the solar array and separate the connectors as quickly as possible to prevent arcing.

TIP To start a compressor an Isc of more than 2A is required. To start both compressors on a refrigerator/freezer an Isc of more than 5A is required.

Checking a one module PV array

Unless you have bright direct sunshine it's very hard to tell whether the PV is producing the correct amount current. This table will give a rough idea of what Isc and Voc to expect for a typical 60 cell PV in different cloud conditions. **If possible it is best to check the PV in bright direct sunlight from 10.30 am until 1.30 pm (1.5 hours either side of midday).**

Cloud conditions		Indicative short circuit current (Isc)	Expected open circuit voltage (Voc)
Bright direct sunshine 1000 W/m^2		8.6 Amps	30- 40V
High thin cloud 500 W/m^2		4.3 Amps	30-40V
Overcast 100 W/m^2		0.9 Amps	30-40V
Heavy rain 20 W/m^2		0.2 Amps	30-40V

Checking a two or three module PV array

If you have a two or three module array you can check the individual modules by comparing the short circuit currents to each other.

If possible, it is best to check the PV array in bright direct sunlight from 10.30 am until 1.30 pm (1.5 hours either side of midday).

Use a cloth or sheet of cardboard to completely cover the array and then disconnect all the panels from each other.

Make a table like this and measure the Isc and Voc for each individual module.

Time of day:	**Date:**	**Weather conditions:**
Module.	**Short circuit current**	**Open circuit voltage**
Module 1	*I1*	*V1*
Module 2	*I2*	*V2*
Module 3	*I3*	*V3*

Test	**YES/NO**
Are the values of I1 and I2 (and I3) within 10% of each other?	
Are V1, V2, and V3 all between 30V and 40 V?	

The individual PV panels are all good if the answer for each test is YES.

Now reconnect the solar pannels and the array output cable. Measure and record the Voc for the array by measuring this at the end of the array output cable. If possible measure and record the array Isc as well – this will require a DC clamp meter.

Time of day:	**Date:**	**Weather conditions:**
Module.	**Short circuit current**	**Open circuit voltage**
PV Array		

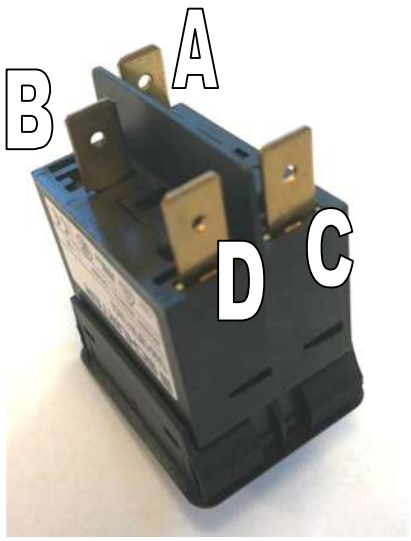
Test	**YES/NO**
Is the array Isc the same as adding I1 and I2 (and I3)	
Is the array Voc the same as each of the individual modules	

TIP! If the tests show that there is a problem it's possible that the light level changed as you conducted the tests. It's worth repeating them again when the light level is more stable.

The PV array and cabling is good *if* the answer the each test is YES.

15. Checking the combined PV isolator and circuit breaker

This circuit breaker automatically disconnects the PV from the refrigerator if it is drawing too much current. It is also used as a switch to manually isolate the PV from the refrigerator, switching it off if not in use or for servicing.



1. Switch PV isolator to “0” to turn it off.
2. Disconnect PV cables from refrigerator.
3. Wait two minutes or more to ensure the capacitor has discharged.
4. Remove SDD controller cover.
5. Make a note of the connections to the isolator switch.
6. Unplug the connecting cables.

Use a mulitmeter to check the following resistances:

Switch position	Where to place multimeter probes	Expected resistance
0	A and C	Greater than 1M ohm
0	B and D	Greater than 1M ohm
1	A and C	Less than 0.1 ohm
1	B and D	Less than 0.1 ohm
1	D and C	Greater than 1M ohm

If any of the above tests fail the circuit breaker should be replaced with the same part.

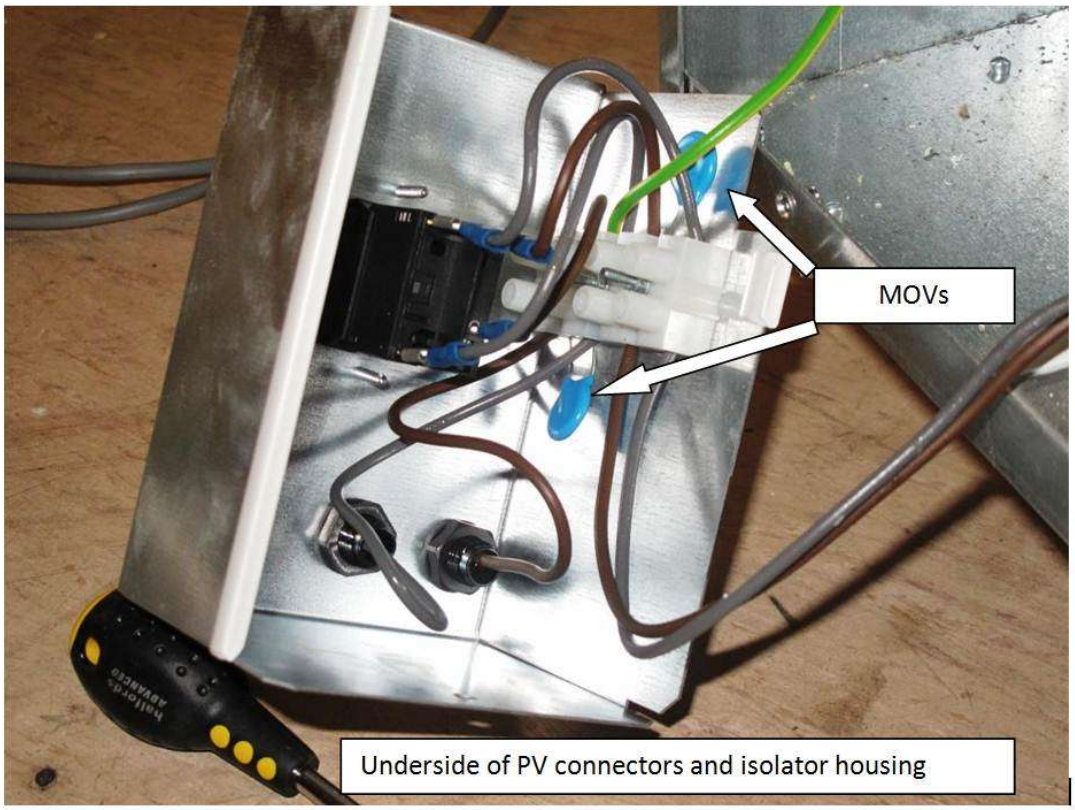
If the circuit breaker is working correctly it can be reconnected and the cover replaced.

16. Checking MOVs on refrigerators without a lightning protection circuit board

There are two Metal Oxide Varistors (MOVs) lightning protection devices. These are designed to absorb voltage surges from small lightning strikes that may occur nearby to the installation but will not be effective against direct lightning strikes.

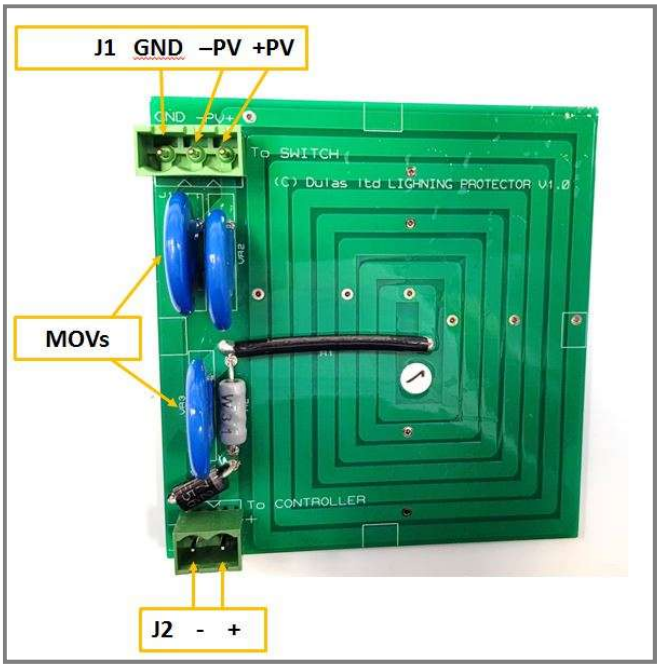
The MOVs are located under the metal mounting cover for the PV connectors and PV isolator. To access:

1. Switch PV isolator to “0” to isolate the PV array.
2. Disconnect the PV cables from the refrigerator.
3. Wait two minutes or more to ensure the capacitor has discharged.
4. Undo the 3 screws to release the cover. Lift it out of the way to reveal the 2 MOV’s mounted to the terminal block underneath.
5. Remove the MOVs using a small screwdriver.
6. Inspect the MOVs. If they are damaged or discoloured they should be replaced. If they look to be in good condition measure their resistance with a multimeter. If the resistance is less than 3M ohms they should be replaced.
7. Either re-install the original MOVs or replace them with new ones and replace the metal cover.



17. Checking the lightning protection board (if fitted)

The Dulas Lightning Protection board incorporates three Metal Oxide Varistors (MOVs) lightning protection devices on the board. These will absorb the small lightning strikes that may occur nearby to the installation but will not be effective against large lightning strikes. If the MOVs are damaged in the event of a large strike they will fail and must the board must be replaced.



To check if the board is still effective conduct the following test:

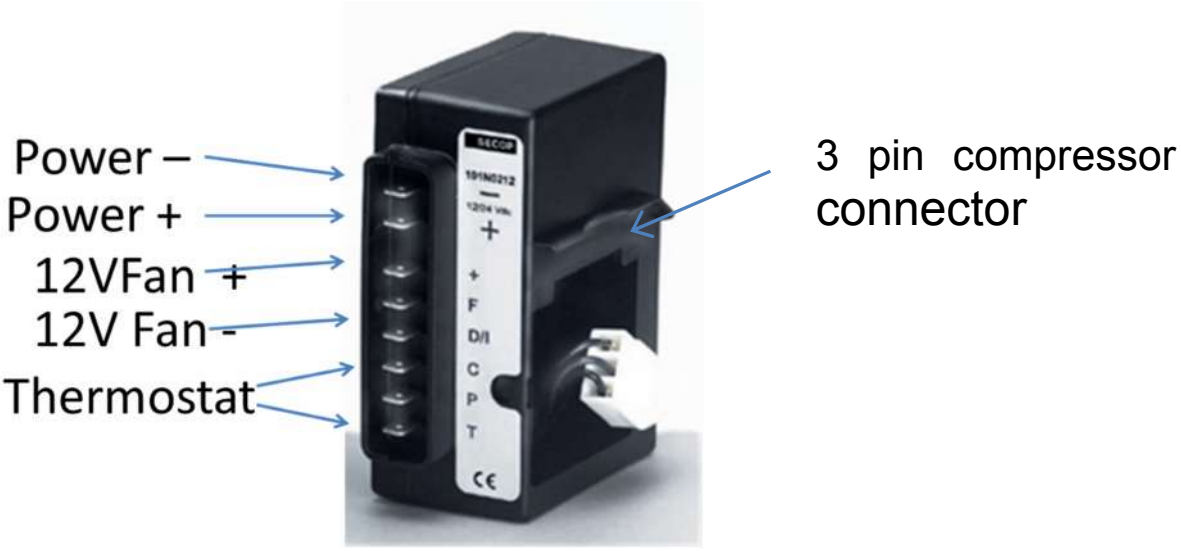
1. Switch the PV isolator to “0”.
2. Wait two minutes or more to ensure the capacitor has discharged and then remove the controller cover.
3. Disconnect the mating connectors from J1 and J2.
4. Ease the 4 plastic clips securing the circuit board to one side and remove the circuit board.
5. Visually check both sides of the board for signs of damage or discolouration.
6. Use a multimeter set to the lowest resistance range to measure the resistance from connection J1/ PV+ to J2/ +. This should be less than 0.15 ohms. It is sometimes necessary to measure the resistance of the multimeter leads shorted together and subtract this “zero” reading from the measured resistance of the circuit board.
7. Use a multimeter set to the lowest resistance range to measure the resistance from connection J1/ -PV to J2/ -. This should be less than 0.1 ohms. It is sometimes necessary to measure the resistance of the multimeter leads shorted together and subtract this “zero” reading from the measured resistance of the circuit board.
8. Use a multimeter set to its highest resistance range to measure the resistance between J2 /+ and J2/ -. This should be greater than 1M ohm. Be careful to ensure that you are not touching the connections as the reading is being taken as this will lower the measured resistance.
9. If all the above tests are satisfactory the board can be re-installed. If any tests fail a replacement board should be installed.

18. Checking the compressor controller

The compressor controller has a 10-45V DC input and provides a low voltage AC output to power the compressor. To turn it on connect the C terminal to the T terminal. It is difficult to check the output of the controller without specialist equipment. It is most straightforward to check that it successfully runs a compressor. To check the controller:

Test No	Test	If the test fails…
1	Ensure that there is DC power from the PV array at the Power – and Power + connections. The voltage should be 24-45V and the short circuit current (Isc) should be greater than 4A.	If no power is present there may be a problem with the SDD controller. Switch the PV isolator to “0” and Temporarily link the PV+ terminal to the F1+ on the SDD controller terminals and go to step 2.
2	Temporarily connect the two thermostat terminals (T and C) together. The compressor should start. Listen for the sound and vibration of the compressor motor.	If the compressor only runs for a few seconds there may be insufficient power from the PV. Check the short circuit current and wait until there is more sunlight. If the PV short circuit current is OK check the compressor winding resistances (see Section 19).
3	Disconnect the connection between the T and C terminals. The compressor should stop.	

If a fault is found with the compressor controller it should be replaced with the SECOP part number 101N0420. Do not use any other part.



19. Checking the compressor

Note: All the Dulas SDD refrigerators use the SECOP BD35K compressor. This is the only compressor that will work with these refrigerators. They are a well-established design and are very robust and do not usually cause problems.

Before testing the compressor confirm that the PV array is working

To test the compressor and compressor controller it can be directly connected to the PV as follows:

1. Switch the PV isolator off (indicated by a “0”).

2. Temporarily link the PV+ terminal to the F1+ on the SDD controller terminals.

3. Temporarily link the thermostat connections (“C” and “T”) terminals on the compressor controller.

4. Switch the PV isolator on. Check that the compressor is running. It will be gently vibrating and drawing a current between 1.3A and 3.5A depending on the temperature of the refrigerator or freezer compartment. A lower current may indicate a refrigerant leak.

5. Switch off the PV at the isolating switch. Now replace the connections to their original condition.

If the compressor doesn’t run check the compressor windings as described below.

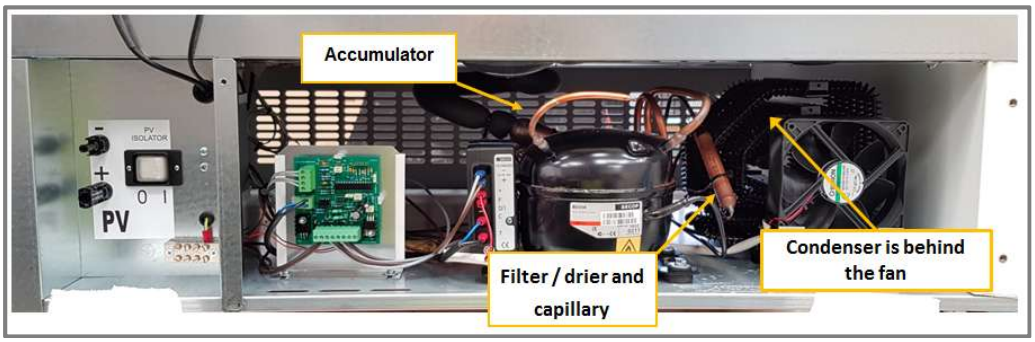
Checking the compressor windings

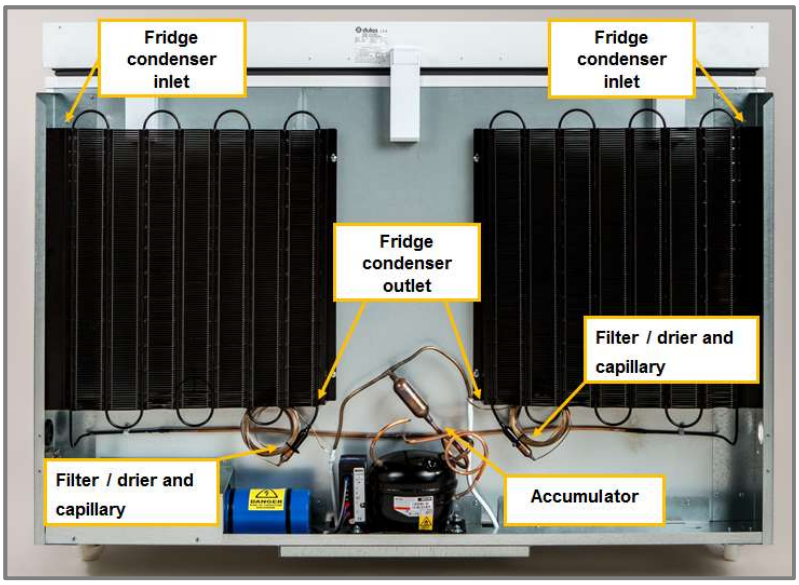
Isolate the PV and remove the compressor controller from the compressor by removing the screw on the front of the controller. Twist the controller sideways until it becomes detached from its mounting bracket.

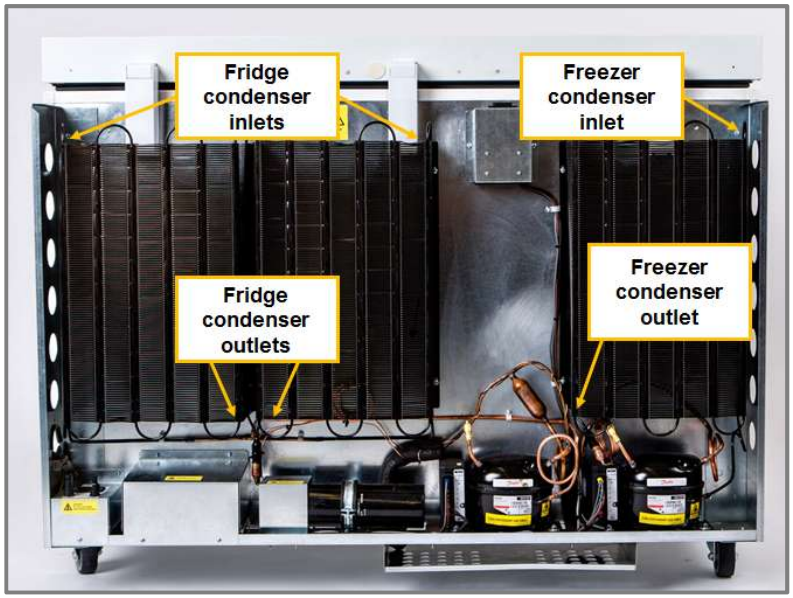
Use a screwdriver to lever the compressor connector from the compressor and check the electrical resistance between each pair of terminals is 1.8 ohms. This is difficult to do. Care must be taken to ensure that there is a good low resistance connection between the mulitmeter probe and the compressor terminal.

20. Checking the refrigeration circuit

Let the compressor run for approximately ten minutes and check the condenser temperature. It should be about 10 to 20 degrees hotter than the surrounding air temperature over most of its surface, hottest at the condenser inlet, and cooler at the outlet. Some Dulas SDD refrigerators have 2 condensers for the refrigerator:







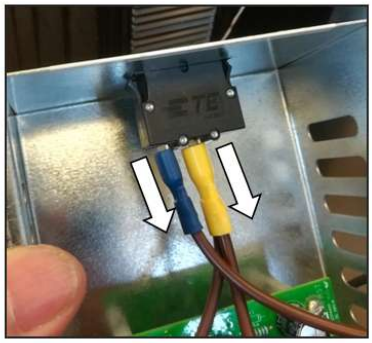
If the condensers do not get warm there is likely to be a gas leak and a refrigeration expert should be contacted to repair it and recharge the refrigerator.

21. VC60SDD-1 and VC150SDD freezer switch replacement

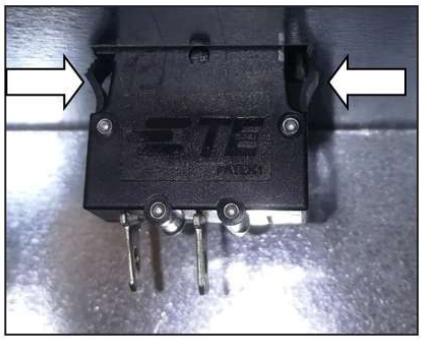
If the freezer switch fails a new switch can be fitted as follows:

1 - Switch PV switch OFF (0).

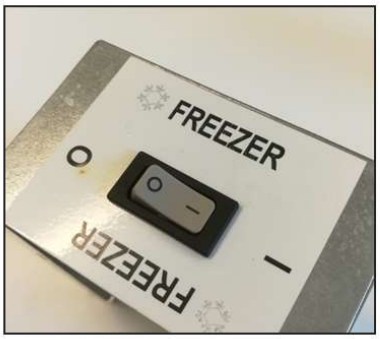
2 - Remove the 2 cover screws and keep safe.



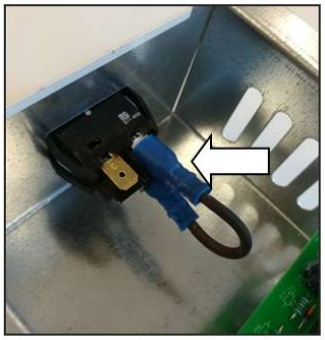
3 - Disconnect existing wires.



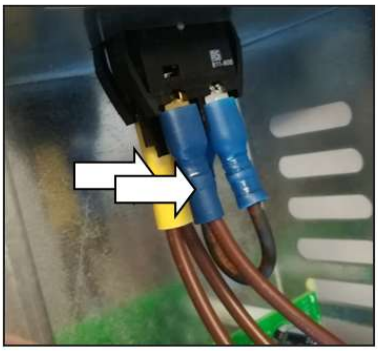
4 - Remove switch by squeezing at the sides.



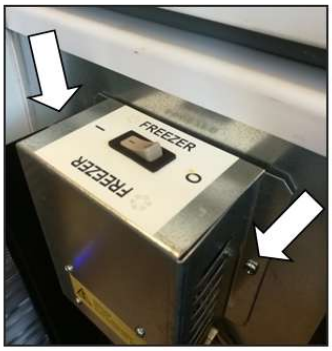
5 - Push in new switch. Make sure it is the right way round.



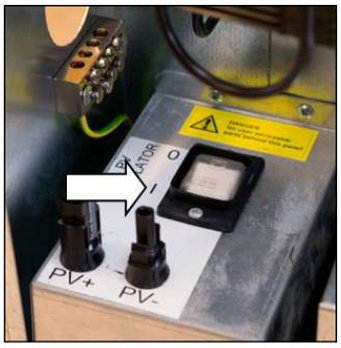
5 - Connect link wire.



6 - Reconnect existing wires.



7 - Screw cover to fridge.



8 - Switch PV switch ON (1) and check that the freezer and freezer fan are working.

For more information contact:
DULAS Ltd, Dyfi Eco Park, Machynlleth, Powys, SY20 8AX, UK
tel: +44(0)1654 705055 fax: +44(0)1654 703000
email: solar@dulas.org.uk
website: www.dulassolar.org