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Breezair ES/EV Control Module Repair Procedure

Make/Model	Date
Breezair ES/EV Control Modules (models with modular communication jack).	01/10/2024

Common Faults

- Corrosion on the solder-side of the PCB will cause various traces to go open-circuit or increase their resistance over time, causing various problems/faults. Quite a lot of these control modules are essentially written-off due to this, as the corrosion is often extensive and all corrosion needs to be addressed in order to perform a high quality repair. A lot of the time, it is not economically viable to repair these control modules to an acceptable standard due to this. As such, we no longer offer repair services for these control modules.

- The fan motor variable speed control circuitry can fail, damaging various components. This is usually caused by fractured solder joints around the pins of the fan motor triac.

- The diagnostic LED (L1) turns solid red after power-up and the cooler won't respond to any commands from the remote/wall control. When the control module is powered on, it should go through a brief start-up procedure, where the fan motor may briefly run and the DIAG LED will flash green/amber in quick succession, before eventually displaying two green flashes every 5 seconds or so. If the control module goes through the start-up procedure and then the DIAG LED (L1) goes solid red, the control module is in a safety shutdown and there is no known way to reset this, as this state is stored inside the microcontroller on the PCB and not in an external EEPROM.

- Corrupt remote control transmission code. This will cause the diagnostic LED (L1) to give a long amber flash when it receives a command from the remote control.

Design Flaws & Remedies

- There are no known design flaws.

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Fault/Status Codes – DIAG LED (L1)

LED Flashes	Description
Solid Red	Safety shutdown. The microcontroller has gone into a safety shutdown and will no longer respond to commands from the remote/wall control. At this time, it is believed that this is a permanent shutdown that can not be recovered from. See "Fault Information – Safety Shutdown (DIAG/L1 Solid Red)" below.
2 (Green)	Normal operation – no faults have been detected by the microcontroller.
1 long amber flash when pressing buttons on the remote control	See "Fault Information – Transmission Code Mismatch (DIAG/L1 Long Amber Flash)" below.
2 (Amber)	The fan motor relay coil has been energised but no feedback from the peak detector circuitry in the fan motor variable speed control circuitry has been detected. Check R1/D1/D2/D3/D4/IC1. Fractured solder joints are common on R1 as it runs hot. Check the variable fan speed circuitry for damage (T1/IC2/R5/R6/etc) for damage. Chjeck that RL1 is functional, check/replace the ULN2003A IC.
None (dead)	Check the fuse near to the mains power connector, check that the fuse holder has continuity when the fuse is installed, check that the isolation switch is in the ON position, check that the fuse/circuit breaker in the distribution board (meter box) has not blown/tripped. Corroding PCB traces or the pins of the LEDs going rusty can also cause the LEDs to stop functioning.

Fault/Status Codes – SAL LED (L2)

LED Flashes	Description
1 RED flash every 2 seconds	Timed drain mode is active (the cooler will drain every 4 hours). This is the default setting after the cooler is first powered on at the mains, after being off. Once the remote has transmitted a command to the cooler, this will change to whatever setting the remote has been set to.
Solid Green	The water salinity is within normal limits or there is no water in the cooler and the cooler is operating with the WaterManager salinity control system enabled. To test the probe and control board, you can short the salinity probe and the SAL LED (L2) should turn solid red shortly afterwards. The salinity probe is located near the pump.
Solid Amber	Water has been detected by the salinity probes but the water is becoming too conductive (too much contamination from salt/minerals/etc).
Solid Red	Water has been detected by the salinity probes but the water is too conductive (too much contamination from salt/minerals/etc). The cooler will drain some water shortly to refresh the water in the cooler.
None (dead)	Faulty control module. Usually due to corroded PCB traces or the pins of the LED going rusty.

Fault Information - Safety Shutdown (DIAG/L1 Solid Red)

At the time of writing, there is no known, public information regarding the reasoning behind the implementation of the microcontroller safety shutdown feature or how to reset the microcontroller once it goes into this state, or if it's even possible. If you do happen to discover how to do this, it would be appreciated if you could pass on the information so that it can be documented and published.

Due to past issues, including lawsuits, it is possible to deduce that the reasoning for this feature is likely for safety reasons and was implemented with very good intentions.

https://www.austlii.edu.au/cgi-bin/viewdoc/au/cases/cth/FCA/2001/1862.html
(see paragraphs 40, 41, 42, 43, 45, 46, 47, 50, & 173 in particular).

TL;DR: In September 1994, Seeley International released a new version of the "EM" coolers that had an innovative wireless RF remote control ("RF Sensortouch") system available as an option. This new system, which comprised of the wireless RF remote control, the cooler control board/PCB and RF receiver, were designed and manufactured for Seeley International, by Cintro Pty. Ltd. and Newtronics Pty. Ltd., respectively. Unfortunately, due to the electrical design of the PCB inside the cooler, it was possible for the run winding in the fan motor to become energised while the start winding was not, even if the cooler was "off". This caused the fan motor to overheat, which resulted in 3 house fires in 4 days in February 2005, caused by roof-top Breezair EM coolers fitted with the Cintro/Newtronics "RF Sensortouch" control system.

Based on the legal document above, the root cause was that the electrical design by Cintro used two triacs to control the power to the motor run winding, and interestingly, a separate relay to control power to the start winding. One triac was a "power" triac, basically operating as a solid-state relay, while the secondary triac was responsible for doing the fan motor variable speed control.

Triacs can fail in some interesting ways. They can fail fully short (stuck on), partially short, or open-circuit. I've also seen defective triacs turn on partially, by themselves, after otherwise operating normally.

With a triac that has gone partially short or that has turned itself partially on, you can get what is essentially pulsed DC, something similar to putting a single rectifier diode in series with an AC power supply (without a smoothing capacitor).

It sounds like the thermal protectors inside the motors did activate as they were supposed to, but that they were unable to break the DC arc, which rendered them useless, resulting in house fires.

The standard approach to this type of circuitry is to have a relay that isolates the mains active from the fan motor and the variable speed control circuitry at the same time. The switched output from the relay goes to one of the motor windings (usually via the run capacitor), and then the power for the triac also comes via the same relay, goes through the triac and then out to the fan motor. You can still end up with only one winding in the motor energised, but it should be AC at the motor, not pulsed DC.

Continued on next page.

Fault Information - Safety Shutdown (DIAG/L1 Solid Red) - Continued

The design of the Breezair ES/EV variable speed fan control circuitry is a safe and standard design, done as described above, where there's a relay that isolates the mains power from the fan motor and variable speed control circuitry at the same time. This design also helps protect the triac and the associated optocoupler, as these components are only exposed to mains voltage (and the transients/spikes/etc. that may come with it) when the fan is running, rather than permanently.

Despite this, this circuitry can and does still fail, sometimes for no apparent reason, other times due to a fan motor over-current event (eg. a short in the windings inside the fan motor), or a fractured solder joint on one of the triac pins where it's soldered into the PCB.

One thing that's slightly unusual about the design, is that they've added a peak detector circuit to give feedback to the microcontroller with regard to the variable fan speed circuitry output. If the triac fails, or if the peak detector circuitry fails, this can trigger the microcontroller to go into the safety shutdown state.

It is not uncommon to see some resistors near to the fan motor triac burnt out, and the microcontroller in a safety shutdown. You can repair the speed control circuitry, but this won't get the microcontroller out of the safety shutdown. At this point, the board is a write-off, unless you can find a spare microcontroller from a donor board of the same model.

After repairing this circuitry, there's also the chance that the microcontroller will enter the safety shutdown state if the repair wasn't sufficient, as the output from the variable speed fan control circuitry may not be what the microcontroller is expecting to see. Experience has proven that it's best to test the repaired board with the fan set to the highest speed, as the output of the variable fan speed control circuitry doesn't appear to be monitored in this case.

Fault Information – Transmission Code Mismatch (DIAG/L1 Long Amber Flash)

The transmission code is programmed into these control modules during manufacturing and printed on a sticker on the control module inside the cooler.

The first 3 digits of the transmission code can be changed using the DIP switches on the control module, but the rest of the transmission code can't be modified. There are 3 DIP switches and they'll be set to ON or OFF depending on the first 3 digits of the transmission code. For example, if the transmission code was "10100000 00", the DIP switch settings would be ON, OFF, ON (ON=1, OFF=0).

Whenever the DIP switches are changed on the control module, the same change needs to be done on the remote, and the control module needs to be turned off for a few seconds and then turned back on.

The first 3 switches on the top row of DIP switches in the remote must match the DIP switches on the control module, otherwise the transmission codes won't match and the cooler will reject the commands from the remote control. The long amber flash indicates that the command has been received but rejected.

Corroding PCB traces inside the control module can cause the transmission code to change by itself, as the resistance of the PCB traces will increase as the corrosion gets worse, eventually causing them to go open-circuit. As such, it can be useful to try setting all 3 DIP switches on the control module to the OFF position, power cycling the control module, and then doing the same in the remote control. Press the ON/OFF button on the remote control a few times and keep an eye on the L1 LED while doing so. If it continues to flash amber, try setting all DIP switches on the control module to ON, do another power cycle, and then change the DIP switch settings in the remote to match. Press the ON/OFF button a few times and see if it works. ***Continued on next page.***

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Fault Information – Transmission Code Mismatch (DIAG/L1 Long Amber Flash)

If the above doesn't get the cooler working, there are at least two more possibilities as to where the problem could be.

If batteries have ever leaked inside the remote control (check for green/corroding battery terminals or rust marks in the battery compartment), the circuitry responsible for setting the transmission code in the remote control may have been damaged. This is because this circuitry is directly behind the battery compartment in the remote control, and the corrosive electrolyte from alkaline batteries will corrode PCB traces, make PCB vias go open-circuit, cause resistors to change value or go open-circuit, cause the contacts inside the DIP switches to make poor connection, and will also usually impregnate the PCB, travel through it and start corroding the button contacts on the other side of the PCB in the remote, which can also cause the remote control to lock up/freeze, due to stray current leaking across the button contacts on the PCB.

Experience has shown that it is not generally economically viable to repair the remote controls, even if the PCB is cleaned and attempts are made to neutralise the electrolyte, problems will usually re-develop a short time later (weeks to months).

If a repair to the remote control is attempted, then it's best to replace all SMD resistors near the battery compartment, replace the DIP switches, clean the bottom half of the PCB with vinegar (both sides, to help neutralise any remaining electrolyte), repair any corroded PCB traces and open-circuit/damaged/corroding vias, clean the rubber button membrane (dishwashing detergent, tap water and a soft brush – nothing more harsh than this or you can damage the carbon pads on the button membrane), clean the plastic case (with vinegar), clean the battery contacts (with vinegar, then use something abrasive to clean them further, and consider tinning them with fresh solder), dry it all thoroughly, put it back together and it might work for a while.

If the electrolyte from the batteries has affected the PCB inside the remote control, the only real cure is to replace the remote control. They're expensive to buy new, and can be difficult to find second hand, especially during summer. Another thing to be aware of is that there are about 3 models. The early ones made by Newtronics won't work on the ES/EV coolers, despite having the same appearance. The newer model with the grey power button will work, assuming the remote control DIP switch settings are set the same as the original remote, and the remote is the only problem.

The next issue that can cause a transmission code mismatch is that the pre-programmed transmission code in the control module changes all by itself. I suspect that it may be radio interference that just happens to get the command right to change the transmission code, as the transmission code usually changes fairly radically, not just 1 bit changing like you might expect from a failing EEPROM.

That leads to, how do you recover the new transmission code if this has indeed happened? You could try to guess the code, but you might be there for a while. There's some software available that can talk to these control modules and do a transmission code search. It basically tries all possible transmission codes while you monitor the control module, listening for the click of a relay. When you hear the click, you immediately hit the space bar to stop the search and the transmission code will be on the screen. The software emulates the wireless remote control protocol, giving the PC full control over the cooler. Other than being able to control all aspects of the cooler, the software has extra features for diagnostic purposes.

The software works on Windows and macOS, it requires a USB<->Serial adaptor (TTL level, eg. an FT232RL-based board, NOT RS-232), and you will need to connect it to the control module via the communication jack. The software is only available upon request, and if provided to you, you are not permitted to distribute it or use it for commercial purposes.

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Breezair ES/EV Control Module Repair Procedure

Standard Reconditioning Procedure

- If necessary, perform minimal repairs in order to get L1 functional and check that the microcontroller is not in safety shutdown.
- Remove all film capacitors.
- Remove all electrolytic capacitors.
- Remove all relays.
- Remove all optocouplers.
- Repair all corroded/corroding PCB traces – grind off solder mask and corrosion with engraver pen, repair as necessary and tin any exposed copper.
- Replace all film capacitors.
- Replace all electrolytic capacitors.
- Replace all relays.
- Replace all optocouplers.
- Check for and address any other component damage.
- Re-solder R1.
- Clean the PCB with IPA to remove flux residue.
- Coat the solder-side of the PCB with APL.

Cleaning Remote Control Battery Terminals

The method below describes an effective way of cleaning battery terminals damaged by leaking batteries:

- Desolder the battery terminal wires from the PCB. Take a photo or make a note of where the wires were so that you can solder new wires back into the same locations.
- Remove the battery terminals from the remote. Desolder or break the wires off of the battery terminals.
- Soak the battery terminals in cleaning vinegar or white vinegar for 5-10 minutes. Cleaning vinegar should have a higher concentration of acetic acid, which will work faster.
- Clean the battery terminals with a brass brush.
- Prepare the following solution in a saucepan:
  - 1 cup white vinegar or ½ cup cleaning vinegar,
  - 3 cups water,
  - 1 tablespoon salt.
- Boil terminals in this solution for about 15 minutes or as long as necessary.
- The copper battery terminals should be fairly clean now. Clean the +/- terminals with a brass brush.
- Rinse the battery terminals in fresh water.
- Dry the battery terminals with hot air.
- Tin the battery terminals with fresh solder, clean with IPA or similar afterwards to remove any flux residue.
- Solder new wires onto the +/- battery terminals, re-install the terminals into the remote control enclosure and solder the +/- wires to the PCB.

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Breezair ES/EV Control Module Repair Procedure

Original Component Values (incomplete)

Resistors: CF=Carbon Film, MF=Metal Film, CC=Carbon Composite

Electrolytic Capacitors:	**Film Capacitors:**	**Ceramic Capacitors:**	**Resistors:**
	C4: 100nF 250VAC X2 C5: 100nF 250VAC X2	C2: 100nF (104)	R3: 820R 1W CF R4: 100R 1/2W CF R5: 100R 1/4W CF R6: 680R 1W CF
Semiconductors:		**Relays:**	
T1: BT139F-800 IC1: IC2: MOC3052 IC6: MC34064P-5		RL1: Siemens V23077-A1005-A402 12V DC 16A RL2: NAiS SPDT 12V DC 10A RL3: NAiS SPDT 12V DC 10A RL4: NAiS SPDT 12V DC 10A	

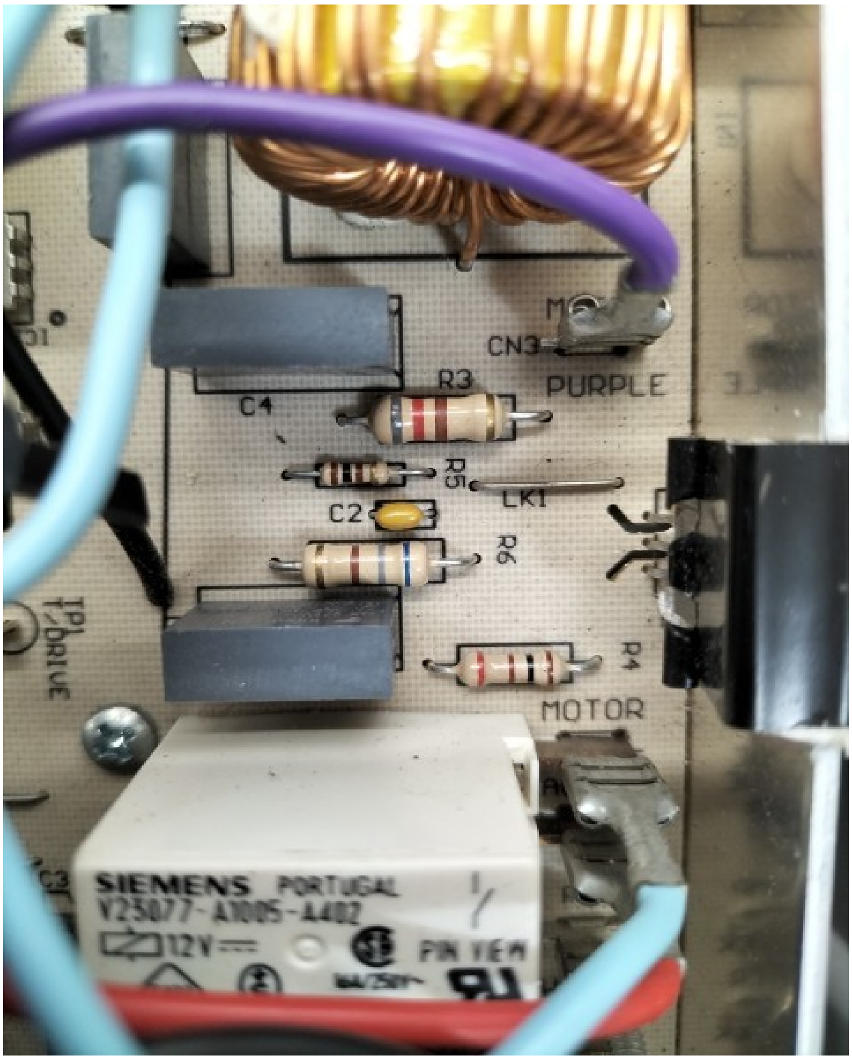

Figure 1: Photo of variable fan speed control circuitry

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Breezair ES/EV Control Module Repair Procedure

Microcontroller (MCU) Pinout (models with modular communication jack)

Revision: 20190720-1950
N/C = Not Connected

Pin	*Function*
1	SW1-1 Input (LOW if switch is ON)
2	SW1-2 Input (LOW if switch is ON)
3	GND
4	N/C
5	50Hz square-wave output from MCU to water salinity circuit, 50% duty cycle. This drives a couple of transistors which in turn make equal positive and negative going pulses of DC across the salinity probes (probably to prevent electrolysis). The square-wave seems to be present at all times.
6	RL4 On/Off (High = On) - Supplies 240V to drain valve via relay
7	RL3 On/Off (High = On) – Supplies 240V to water manager module
8	RL2 On/Off (High = On) – Supplies 240V to run water pump
9	RL1 On/Off (High = On) – Supplies 240V to fan motor and associated fan speed control circuitry
10	Salinity Level (voltage for A/D conversion from LM324 op-amp). Approx 0V when no water present or probes open-circuit. At approx 1.4V the salinity LED (L2) will turn yellow/orange. If probes are shorted, L2 will turn red. Water manager relay will turn on after a delay and then turn off again once salinity reduces (resistance of probes increases and voltage at this pin will drop).
11	Vcc +5V
12	Vss (GND)
13	N/C
14	SW1-3 Input (LOW if switch is ON)
15	Minimum Fan Speed (voltage from fan speed adjust potentiometer for A/D conversion)
16	L2 (Salinity LED) On/Off (Green) via TR5 (PNP/BC557)
17	L1 (Diagnostics LED) On/Off (Green) via TR6 (PNP/BC557)
18	L1 (Diagnostics LED) On/Off (Red) via TR7 (PNP/BC557)
19	L2 (Salinity LED) On/Off (Red) via TR8 (PNP/BC557)
20	To 8.000 MHz Crystal (OSCin)
21	To 8.000 MHz Crystal (OSCout)
22	MCU Reset (low voltage detection provided by IC6/MC34064P-5)
23	Mains AC Peak Detector Input (100Hz Square-wave)
24	L3 On/Off (Sinking current via MCU)
25	Wall Control Data Output
26	Wall Control / Remote Control Data Input
27	Motor TRIAC drive (via optocoupler IC2)
28	Feedback from motor speed control circuitry via optocoupler IC1. This is a 100Hz square-wave. Duty cycle of the waveform will change as motor speed is changed due to the triac on-time changing. This circuit allows the control module to sense if the motor has gone open-circuit or isn't connected. There is no feedback available at maximum speed as the triac is always on and this circuit can't provide feedback to the MCU. The fan motor can go open-circuit when set to full speed and the MCU won't notice.