Adaptive Defrost Control
ADC

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Adaptive Defrost Controls (ADC)

- Defrost system which adapts to a refrigerator’s surrounding environment and household usage.

- A microprocessor or electronic control defrost timer allows defrost to occur only when needed, compared to mechanical timers which defrost at a preset interval whether it is necessary or not. Such as every 6 hrs for 22 min.
Adaptive Defrost Controls (ADC)

• ADC will continually adjust defrost intervals based on following:
  o Number of door openings (some)
  o Compressor run time
  o During defrost cycle, the board monitors how long the defrost termination thermostat keeps the heater energized.
    ▪ If the defrost termination tstat. Opens in less than the average 12 min = light frost build up, board will increase the amount of run time between defrost by about 2 hours.
    ▪ If the defrost termination tstat. Opens in more than 12 min = heavier frost build up, board will decrease the time between defrosts by aprox. 2 hours.

• Forcing unit into defrost varies from unit to unit. Refer to units technical data sheet.
Defrost Heaters

- High wattage electrical elements that generate a great deal of heat when power applied to it.
- Come in two varieties:
  - Calrod heaters
  - Glass enclosed heaters
Defrost Termination Thermostat (Bimetal)

- Utilizes a bimetal disc to sense temperature.
- When exposed to temperature changes, the disc warps, making or breaking a set of electrical contacts.
- Contacts open at approx. 43°F and close at 15°F. (Thermistors open at 50 to 70 F)
- 2 main purposes:
  - Prevents the defrost heater from energizing unless the freezer is at the correct temperature
  - Opens the circuit to the heater at the completion of the defrost cycle.
WHIRLPOOL ADC SYSTEM
Whirlpool ADC

Adaptive Defrost Control Board Variations

• **ADC**- Adaptive Defrost Control Board only
• **ADC/WFI**- Adaptive Defrost Control Board with Water filter Indicator
• **ADC/FD**- Adaptive Defrost Control Board with Evaporator Fan Delay
• **ADC/FD/WFI**- Adaptive Defrost Control Board, Evaporator Fan Delay and Water Filter Indicator.
Whirlpool ADC System

- **Whirlpool ADC**
  - Initiates defrost only when necessary
  - Mounts same as electromechanical timer
  - 4 wire connector is the same
  - Also connects to brown and white wires
  - ADC Board has no serviceable components
  - Cannot be substituted for regular timer

- **Operation**
  - When first plugged in, unit will defrost after 6 hours of compressor run time
  - Defrost mode lasts 21 or 25 minutes depending on model
  - After initial defrost the ADC:
    - Monitors compressor run time
    - Monitors defrost heater-on time
    - Adapts from 8 to 100 hours between defrosts depending on model SMART controls
Whirlpool ADC System

ADC Circuit Board Assembly

[Diagram of ADC Circuit Board Assembly]
The ADC control is supplied 120 v at pins #1 and 6.
Whirlpool ADC System

Cooling Mode

• The ADC supplies 120 vac to the cooling circuit out of pin #4

• Input on pin #3 of ADC monitors Compressor run time
Whirlpool ADC System

Defrost Mode

• ADC supplies 120 vac to the defrost circuit from pin #2

• Input on Pin #5 of ADC monitors heater-on time
Testing and Diagnosis

- **First ADC Test Method:**
  - Turn thermostat off for 15 seconds
  - Turn thermostat on for 5 seconds
  - Repeat the above two more times
  - In 3 to 8 seconds ADC goes into defrost mode
  - If ADC fails to go into test mode, try second test mode

- **Second ADC Test Method:**
  - Unplug unit from wall outlet for 30 seconds
  - Turn thermostat off
  - Plug in unit
  - In 3 to 8 seconds ADC goes into defrost mode
  - If ADC fails to go into test mode, check the bimetal

**Helpful Hint:**
Upon entering the test mode, the relay mounted on the ADC board should turn the compressor off and the defrost heater on. Listen for the relay to click, and then listen for up to 30 seconds for a second click. If you hear one click, check the defrost heater for continuity. If you hear two clicks, check for an open bimetal.
MAYTAG ADC SYSTEM
Maytag ADC System

- Maytag produced refrigerators with adaptive defrost were produced in 2 different locations.
  - Galesburg- numbers 361A can be found near the UL certification on the model tag
  - Amana site- numbers 165A can be found near the UL certification on the model tag

- **Galesburg Produced Platform (361A) before June 2003.**
  - To Initiate Forced Defrost Cycle: jump L1 to Test point
  - To Terminate: Disconnect power.

- **Amana produced Platform (165A) before June 2003**
  - Initiate Forced Defrost Cycle: Cycle door switch five times within 6 sec. Could be either the fresh food door sw or the freezer door sw. Refer to service info to determine which sw is connected to the DR SW terminal on the ADC Module.
  - To Terminate: Cycle door sw five times in 6 sec.
Amana platform produced after June 03 and Galesburg platform produced after April 03.

- Cycle cold control on and off three times in six sec.
- Cold control needs to be left in the closed position (calling for cooling) for the defrost system to energize on all platforms.
- It is not enough to cycle the cold control knob, the contacts must actually open and close.
- In most cases, you can hear the contacts open and close if they are doing so.
- To terminate defrost cycle: disconnect power for five seconds.
Maytag ADC System

- Initiates defrost only when necessary
- Mounts same as electromechanical timer
- Cannot be substituted for regular timer

**Operation**
- After initial power up, defrost interval is 4 hours compressor run time. Defrost occurs immediately after the 4 hours.
- Once unit is ready to defrost there is a 4 minute wait time prior to the beginning of the defrost cycle.
- Optimum defrost is 15 min.
- When defrost thermostat opens there is a 4-6 minute drip time before compressor restarts or Control Board will terminate defrost at 25 min if defrost thermostat has not opened and will reset the defrost interval to the 8 hr. minimum setting.
Maytag ADC System

- L1 and TEST jumped puts this Maytag control into TEST.

- Should get 120v DEF to White if the relay closed
Testing the Maytag ADC (SxS)

- The unit must be running (if not the ADC will cycle through the test mode in 2 seconds)
- Disconnect plug from wall.
- Remove & Drop component housing.
- Connect Amp meter to Yellow
- Reconnect plug
- Apply screwdriver between L1 and Test for 3 to 4 sec. Then remove. You should hear a relay click.
- 23 minute Defrost Cycle initiates.
- Compressor and fans turn off.
- Amp draw is approx 4.5 or 500-600 watts.
- Disconnect plug
- Perform resistance checks.
- Reconnect plug to reactivate Run Cycle.
Maytag ADC System

- **Testing the ADC on top Mounts**
  - Disconnect from power source
  - Remove light shield
  - Connect watt or amp meter to refrigerator
  - Using an insulated #22 jumper wire between L1 and Test
  - Energize unit and make sure compressor is running.
  - This will activate the refrigerator into a defrost for approximately 23 minutes
  - Wattmeter should read 500-600 watts. Amp meters should read 4.5 amps

**NOTE:** if the temperature control is open (unit not running) and jumper L1 and Test, the unit will cycle through the test mode in two seconds and there will be no amp/watt draw.
FRIGIDAIRE ADC SYSTEM
Frigidaire ADC System

• **WCI ADC**
  - The board operates at 115 VAC, supplied by the Cold Control (orange wire.)
  - Defrost termination (blue) sensing is between the defrost heater and the bimetal thermostat. The heater is on the hot side of the line and the bimetal on the neutral.
  - The ADC will dissipate an average of no more than 0.4 watts.
  - Normal operating life is 22,000 defrost cycles over a 15 yr. period.

• **Operation**
  - When power is applied to the power cord:
    - If the defrost termination tstat is closed, a cycle will be initiated after 1hr.
    - If the defrost termination tstat is open, a compressor cycle starts immediately.
  - The ADC is based on 6 hours compressor run time.
  - The maximum defrost cycle must be terminated after 24 min. + 6 min drip time.
Frigidaire ADC System
System Diagnostics

- To enter unit into defrost manually depress the light switch five times within a 6 second time period.
  - If a defrost is initiated manually and the termination tstat is closed, the heater will be actuated until the termination tstat opens.
  - A 6 min drip times follows before compressor is energized.
**Vacation Mode:**

- Defrost interval = 12 hours + door has not been opened in the last 24 hrs.
- Defrost heater will come on after 72 hours.
  - If door still not opened and heater On time is < than 16 min. then the defrost heater is turned on after 72 hrs.
  - If door is opened but heater runs longer than 16 min. then the defrost will restart after 6 hrs.
- Once the unit is on Vacation mode, if the door is opened and the compressor run time since the last defrost has been at least 5 hrs a defrost is initiated after 1 hr of compressor run time since last door opening.
TMNF Adaptive Defrost

**MODELS:**
- GTH/HTH 16 cu ft
- GTH/HTH 17 cu ft
- GTH/DTH/GTS/PTS 18 cu ft
Adaptive Defrost Control Access

- Once you have removed the control housing from the ceiling of the refrigerator; you will see the control box that houses the defrost control board.
- To open the cover, remove the push pin.

Decatur Model Control Housing Shown
Adaptive Defrost Diagnostics

Product Service and Test considerations

**Immediate Diagnostic Defrost**

Product service has the need to be able to initiate a defrost upon request. To implement this, the product service person must press the fresh food door switch three (3) times within five (5) seconds when the control is not already in defrost or dwell. Pressing this switch in this way will initiate an immediate (no pre-chill) defrost unless the control is already in the Defrost or Dwell States. After this defrost is initiated, the normal defrost sequence will follow and the normal rules will determine the start of the next defrost.

**Terminate Diagnostic Defrost**

Product service also has the need to be able to terminate a defrost upon request. To implement this, the product service person must press the fresh food door switch three (3) times within five (5) seconds when the control is in either defrost or dwell. Pressing this switch in this way will terminate the defrost and initiate a first cycle state.
Adaptive Defrost Control Operation

First Cycle --- Due to the unknowns after a power failure, the control will monitor the compressor run time after a power failure through the CR terminal. If the control determines that the compressor has turned off during the Normal Power Up Time period hours), the control will enter Pre-Chill and a normal defrost condition. If the control determines that the compressor has not turned off during the Normal Power Up Time, (warm cabinet) the control will enter the Pull Down state.
Adaptive Defrost Control Operation

Pull Down monitors the compressor run time from the CR terminal for the Pull Down Time and immediately enters a defrost without a pre-chill at the end of the Pull Down Time of 5 hours or a total of 7 hours.

There are three different defrost algorithms.
1. Maximum 40 minutes timed from the defrost board.
2. Defrost not terminated within 30 minutes.
3. Normal defrost – termination in less than 30 minutes.

The board monitors the defrost time through the DT terminal.
Adaptive Defrost Control Operation

Abnormal is entered when the defrost time has been longer than 30 minutes. This also includes when the defrost is time terminated at 40 minutes. When in the Abnormal state, the control will enter the next defrost after a fixed amount of compressor run time, called the Abnormal Run Time or 8 hours.
Adaptive Defrost Control Diagram

The compressor operation is controlled by the cold control which is external to the defrost control. The defrost control is summing the compressor run time by monitoring the Compressor voltage at pin CR. The defrost control is also monitoring the Fresh Food and/or Freezer door open times through the FF/FZ pins and is reducing total run time till next defrost by a factor times the door open time.*

* 3 minutes for every second of door opening.
Adaptive Defrost Control Diagram

Pre-Chill

The compressor is being controlled by the K1 relay. The K1 relay is on during the Pre-Chill Time period for 1.5 hours. So it is possible to find a unit running with the cold control in the open state during Pre-Chill.

No adaptive inputs will affect the timing during Pre-Chill.

The K1 Compressor relay is not shown in the schematic diagram.

The CR terminal is a normally open contact of the K1 relay.
Adaptive Defrost Control Diagram

Defrost

The compressor is turned off and the defrost heaters are turned on by operating the K2 relay. During this time, the defrost termination is monitored to determine when it opens through the DT pin. If it opens during the defrost time, the heaters will be turned off and the control should immediately enter the dwell state. If the terminator does not open during the defrost time, defrost will be terminated by time (40 minutes) and the dwell state will be bypassed.

No adaptive inputs will affect the Defrost timing.
Adaptive Defrost Control Diagram

Dwell

During the 5 minute Dwell time, the K2 relay continues to keep the compressor off.

No adaptive inputs will affect the Dwell timing.
Adaptive Defrost Control Diagram

Dwell

During the 5 minute Dwell time, the K2 relay continues to keep the compressor off.

No adaptive inputs will affect the Dwell timing.
No Door Input Defrost Control Diagram

Note that some models do not have door switch inputs to adjust adaptive defrost time. These units will use compressor 8 hour run time only for the defrost timing. You will not be able to force a diagnostic defrost on this type unit.

On these units you can check resistance of the defrost circuit on a cold cabinet from DF Blue to L2 Orange wires to verify the defrost circuit.

You can also check the defrost heater independently from DF Blue to DT Pink.
GE ADC SYSTEM
**Initial Cycle**

- When unit first connected to power and turned on the electronic control must determine whether is a new installation or a power interruption.
- Decision is based on temperature of the freezer section.
  - **If freezer section too warm (>60°F):**
    - E.C. assumes is a new installation
    - Unit will enter Pull-Down Mode (all data recorded in memory are cleared and counters are reset to zero.
  - **If freezer section is cool:**
    - Control assumes the refrigerator must have experienced a temporary power outage and continues operating with the inputs stored in memory.
Pull Down:
- Control will run the cooling cycle until eight hours of accumulated compressor run time then enter prechill and begin a defrost cycle.
- After defrost cycle, dwell time and post dwell, normal cooling operation with adaptive defrost will begin.
- Control will begin monitoring door openings and compressor run time.

GE ADC System
GE ADC System

- An electronic control board that will decide when the unit goes into defrost base on:
  - Length of time the refrigerator doors were open since last defrost.
  - Length of time compressor has run since last defrost.
  - Amount of time the defrost heaters were on in the last defrost.
- Unlike other brand refrigerators, GE will enter into a **Prechill** mode just prior to the defrost heater operation.
  - Electronic control bypasses the freezer thermistor input and forces the compressor to run constantly for appr. 1 to 2½ hrs.
- During defrost, the electronic control monitors defrost heater operation (ON time).
- Once heater operation terminated, the e.c. will allow for a **Dwell Time** before initiating the next cooling cycle.
  - Elapsed time from heater termination until cooling operation is resumed.
- After dwell time the control will begin a **Post Dwell** period.
  - Compressor and condenser fan operate but the interior fans will be off to allow the evaporator coil to cool down before the fans circulate air.
**Operation:**

- The Electronic control receives inputs and provides output from many different locations on the board.
  - Inputs - inputs from various fridge operations (door openings, control settings, thermistor readings, etc)
  - Processing Unit – Decision making occurs (when to defrost, to run the compressor, etc)
    - These decisions are based on inputs the control has received and even after power failures the information is retain.
  - Outputs – all of the work is performed (relays open and close to initiate and terminate various operations i.e. defrost, cooling, etc)
• **Cooling Operation**
  - Electronic control monitors door opening times and compressor run times.
  - Times are accumulated unit = 60 hours of total equivalent compressor run time.

\[
\text{Total equivalent compressor run time (minutes)} = \left( \frac{\text{Accumulated door open time (minutes)}}{\text{Multiplication Factor}} \right) + \text{Accumulated compressor run time (minutes)}
\]

**NOTE:** Multiplication Factor = 1 minute of door open time is equivalent to between 120 to 255 minutes of compressor run time (depending on model)

• Unit then enters the Prechill mode.
GE ADC System

**Prechill**
- A minimum of 8 hrs accumulated compressor run time plus 60 hours of total equivalent compressor run time = electronic control will force unit into a continuous cool mode (Prechill).
- Compressor must be running.
- Last approx 1 to 2 ½ hrs.
- Compressor, evaporator fan and condenser fan will run for the entire cycle.
- Input from the freezer thermistor is ignored at this time.
- Freezer temp. is lowered approx 15 to 20° F causing the compressor run time to be reduced. Taking less time for the freezer to reach its temp. setting.
**Defrost Operation**

- After 2 hrs of prechill have completed, the e.c. turns off the compressor, condenser fan and evaporator fan.

- Control energizes the defrost relay to complete the defrost heater circuit.

- E.C. monitors heater ON time. This information is used to determine how much frost has accumulated on the evap. coils.
Defrost Operation

- There are two possible defrost operations:
  - **Normal Defrost Operation**: defrost heater operation is terminated by the evaporator thermistor in less than 30 min of heater operation.
  - Once heater off, there is a fixed 5 minute dwell time followed by a post dwell period before cooling starts.

- **Abnormal Defrost Operation**: defrost heater operation is terminated by the evaporator thermistor within 30 to 45 min of heater operation.
  - Once the defrost heater is off, there is a fixed 5 minute dwell time, followed by a post dwell period before cooling operation is resumed and non-adaptive defrost.
• **Dwell Period**
  - Elapsed time from heater termination until cooling operation begins.
  - Compressor, condenser fan and evaporator fan remain off.
  - Remaining frost melting from the evaporator will continue to drip and drain, clearing evaporator from any moisture.
- **Post Dwell:**
  - Designed to cool the evaporator before circulating air within the refrigerator.
  - Prevents any residual heat on the evaporator from defrost from being distributed in the freezer.
  - Compressor and condenser fan are on. Interior fans are off and damper is closed.
  - Depending on model the e.c. will start the evap. fan.
**Normal Adaptive Defrost**
- At the end of a normal defrost cycle, the electronic control will return the refrigerator to a normal cooling operation.
- Control will monitor accumulated door open time and actual accumulated compressor run time.
- Once 60 hours of total equivalent compressor run time is reached, the next defrost cycle will occur.

**Abnormal Adaptive Defrost**
- At the end of an abnormal defrost cycle, the electronic control will return the refrigerator to a normal cooling operation.
- Due to abnormal amount of heater On time during the defrost cycle, the control will initiate the next defrost operation after a fixed 8 hrs of accumulated compressor run time (non-adaptive defrost operation).
GE ADC System

Adaptive Defrost Flow Chart

- **POWER UP**: Just plugged into power source or restarting after power interruption
  - **Power UP Test**: 2 seconds

- **Initial Cycle**: Control measures temperature of freezer section
  - Is the freezer temperature above 60°F?
  - Pull Down Mode: 8 hours of accumulated compressor run time occurred?

- **Defrost Mode**: Refrigerator enters defrost cycle in the mode
  - Was the unit in defrost when power was lost?

- **Cooling Operation**: Have 60 hours of total equivalent compressor run time occurred?
  - Continue
Cont.
Self Diagnostics

To enter Self Diagnostic mode, both temperature control panel displays must be illuminated. A display can be illuminated by pressing an adjacent temperature adjustment button. When both displays are illuminated, set the freezer and refrigerator temperature settings to 5. Simultaneously press and hold all 4 temperature adjustment buttons for approximately 3 seconds. A flashing 0 in the refrigerator and freezer displays will indicate that the refrigerator is in Self Diagnostic mode.

To perform a self diagnostic test, locate the test in Table 2, Diagnostic Tests.

For temperature control panels with single-digit displays, the COLDER temperature adjustment button will increment the numbers up and the WARMER temperature adjustment button will increment the numbers down. Use the freezer temperature adjustment buttons to enter the test code number in the freezer display. Use the refrigerator temperature adjustment buttons to enter the test code number in the refrigerator display. When a test code has been entered, the displays will flash to confirm the test. Press the HOLD button for 3 seconds to begin the test.

For temperature control panels with 3-digit displays, the COLDER temperature adjustment button will increment the numbers down and the WARMER temperature adjustment button will increment the numbers up. Use the freezer temperature adjustment buttons to enter the test code number in the freezer display. Use the refrigerator temperature adjustment buttons to enter the test code number in
the refrigerator display. When a test code has been entered, the displays will flash to confirm the test code. Press any button other than a temperature adjust button to begin the test.

When testing has been completed, do one of the following things:

- Enter code 15 to completely reset the system.
- Enter code 16 to exit diagnostic mode. The temperature control panel is reset automatically.
- Unplug the refrigerator for at least 10 seconds. Test mode will terminate when the refrigerator is plugged back in.

Test mode will terminate automatically after 15 minutes of inactivity.

Temperature Control Panel (Single-Digit Display)
<table>
<thead>
<tr>
<th>Freezer Display</th>
<th>Refrigerator Display</th>
<th>Mode</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2</td>
<td>Temperature control panel to main control board communication</td>
<td>P on the FZ display if OK. F on the FZ display if not OK.</td>
</tr>
<tr>
<td>0</td>
<td>3</td>
<td>Temperature control panel to dispenser board communication</td>
<td>P on the FZ display if OK. F on the FZ display if not OK.</td>
</tr>
<tr>
<td>0</td>
<td>4</td>
<td>Dispenser board to main control board communication</td>
<td>P on the FZ display if OK. F on the FZ display if not OK.</td>
</tr>
<tr>
<td>0</td>
<td>6</td>
<td>Temperature control panel self-test</td>
<td>See Temperature Control Panel Self-Test on page 35.</td>
</tr>
<tr>
<td>0</td>
<td>7</td>
<td>Control and sensor system self-test</td>
<td>See Control and Sensor Self-Test on page 36.</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>Open damper</td>
<td>Damper will open, pause briefly, then close.</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>Fan speed test</td>
<td>Each fan will run for 10 seconds, then stop.</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>100% run time</td>
<td>This mode runs the sealed system 100% of the time for 1 hour.</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>Enter pre-chill</td>
<td>This places the freezer in pre-chill mode. The refrigerator will return to normal operation on its own.</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>Enter defrost</td>
<td>This will set the refrigerator into the defrost mode. If the cabinet is not cold when executed, this mode may execute extremely fast. The refrigerator will return to normal operation on its own.</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
<td>Refrigerator reset</td>
<td>Causes a system reset.</td>
</tr>
<tr>
<td>1</td>
<td>6</td>
<td>Test mode exit</td>
<td>Causes system to exit test mode and resets temperature control panel.</td>
</tr>
<tr>
<td>1</td>
<td>7</td>
<td>Degree C/F</td>
<td>Refrigerator temperature adjust keys can be used to change display from F to C or C to F.</td>
</tr>
</tbody>
</table>
Communication Tests (0 2, 0 3, or 0 4)

A communication test will display the test code while checking communication. When the test has concluded, the freezer display will display a P (passed) or an F (failed) for 2 seconds. After 2 seconds, the displays will show the test code. At this time, a new test code can be entered.

Temperature Control Panel Self-Test (0 6)

This test applies only to the temperature control board inside the fresh food compartment.

When the Temperature Control Panel Self-Test is initiated, all of the LEDs and numerical segments in the displays will illuminate. When the SAFE THAW button is pushed, all 3 LEDs for safe thaw should turn off. When the QUICK CHILL button is pressed, all 3 LEDs for the quick chill should turn off. Continue this process for each LED/Button pair on the display. The colder key is to turn off seven-segment LEDs. The warmer key is to turn off the Set LED for both the freezer and the fresh food compartments.

To exit the Temperature Control Panel Self-Test, both of the refrigerator temperature adjust keys must be pressed simultaneously for 3 seconds. This can be done at any time to exit the test.
Control and Sensor System Self-Test (0 7)

This test checks all five thermistors located throughout the unit. Once the test is initiated, the test code (0 7) will stop flashing and the thermistor test results will appear on the freezer display in the test order listed below. The thermistor test sequence number will not be shown on the display.

If the unit is not equipped with the Quick Chill option, the third thermistor (quick chill) will display a 0 and 3 audible beeps will sound at the temperature control panel. This is not a failure if the unit is not equipped with the Quick Chill option.

Thermistor test results:
• P = Pass
• 0 = Failed
• S = Short to 5 VDC
• B = Bad amplifier

Thermistor test sequence is:
1. Fresh food top thermistor
2. Fresh food bottom thermistor
3. Quick chill thermistor (displays 0 if unit is not equipped with Quick Chill option)
4. Evaporator thermistor
5. Freezer thermistor

Note: Thermistor test results will be displayed in the sequence shown above. The thermistor test sequence number will not be shown on the display.
Diagnostic AID
WX05X14999 Wiring Harness
WR49X10095 Touch Control membrane and housing Kit also has new Main Control Board

<table>
<thead>
<tr>
<th>Temperature Degrees (C)</th>
<th>Temperature Degrees (F)</th>
<th>Resistance in Kilo-Ohms</th>
</tr>
</thead>
<tbody>
<tr>
<td>-40</td>
<td>-40</td>
<td>166.8 kΩ</td>
</tr>
<tr>
<td>-35</td>
<td>-31</td>
<td>120.5 kΩ</td>
</tr>
<tr>
<td>-30</td>
<td>-22</td>
<td>88 kΩ</td>
</tr>
<tr>
<td>-25</td>
<td>-13</td>
<td>65 kΩ</td>
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<tr>
<td>-20</td>
<td>-4</td>
<td>48.4 kΩ</td>
</tr>
<tr>
<td>-15</td>
<td>5</td>
<td>36.4 kΩ</td>
</tr>
<tr>
<td>-10</td>
<td>14</td>
<td>27.6 kΩ</td>
</tr>
<tr>
<td>-5</td>
<td>23</td>
<td>21 kΩ</td>
</tr>
<tr>
<td>0</td>
<td>32</td>
<td>16.3 kΩ</td>
</tr>
<tr>
<td>5</td>
<td>41</td>
<td>12.7 kΩ</td>
</tr>
<tr>
<td>10</td>
<td>50</td>
<td>10 kΩ</td>
</tr>
<tr>
<td>15</td>
<td>59</td>
<td>7.8 kΩ</td>
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<tr>
<td>20</td>
<td>68</td>
<td>6.2 kΩ</td>
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<tr>
<td>25</td>
<td>77</td>
<td>5 kΩ</td>
</tr>
<tr>
<td>30</td>
<td>86</td>
<td>4 kΩ</td>
</tr>
<tr>
<td>35</td>
<td>95</td>
<td>3.2 kΩ</td>
</tr>
<tr>
<td>40</td>
<td>104</td>
<td>2.6 kΩ</td>
</tr>
<tr>
<td>45</td>
<td>113</td>
<td>2.2 kΩ</td>
</tr>
<tr>
<td>50</td>
<td>122</td>
<td>1.8 kΩ</td>
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<tr>
<td>55</td>
<td>131</td>
<td>1.5 kΩ</td>
</tr>
<tr>
<td>60</td>
<td>140</td>
<td>1.2 kΩ</td>
</tr>
</tbody>
</table>