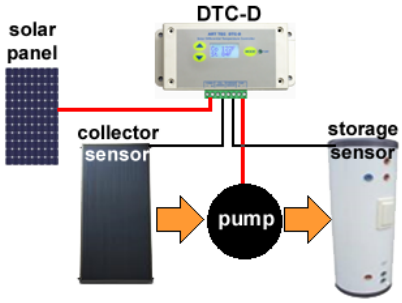
Solar Differential Temperature Controller
Model DTC-D



OVERVIEW

The DTC-D is specifically designed for solar heating applications where the collector circulation pump is powered from a solar (PV) panel, or optionally, battery power or any 12VDC source. Its purpose is to ensure that the collector circulation pump is only activated if the collector is hotter than the storage tank. The differential setting is adjusted to compensate for the temperature drop of the plumbing between the collector and heat exchanger, or storage tank. The maximum temperature limit can be set for the storage tank to prevent excess temperature in the tank, the pump will shut off and optionally an audible warning can be set. Additionally, if collector temperature drops below 35°F an audible freeze warning can be set. The pump can be programmed to continue to circulate (with battery power) until the temperature rises above 35°F to prevent plumbing from freezing.

POWER CONNECTIONS

Connect the solar panel directly to the POWER terminals on the controller, observe polarity. The pump is connected to the PUMP terminals on the controller, again observing polarity. **The DTC-D is optimized for solar power and electronic pumps such as the El-SID or Laing D5 Eco-circ. If using 12V battery power with large pumps, a relay will be required between the controller and the pump.** NOTE that the terminal strip can be removed by pulling it firmly out from the box. Be careful when inserting wire to place it in the upper edge of the hole so that the guillotine style clamp can secure it. Pull test all wires after tightening the screw. ***Be sure to ground all plumbing — especially the collectors — to a reliable earth ground.***

OPERATING MODES

The default operating mode updates the current temperature readings from 0-250F (-18 to 120C) every second and activates the pump according to the programmed set points. Pressing the MODE button briefly allows you to select and change various settings. By pressing and holding the MODE button more than 5 seconds you can manually override the pump to on, off or auto.

BACKLIGHT

Pressing either arrow key activates the backlight for about 15 seconds without affecting the controls. Pressing the MODE button activates the back light for about 5 seconds, each key press resets this time period.

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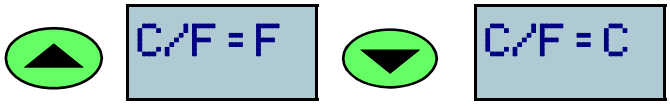
Solar Differential Temperature Controller
Model DTC-D

MIN/MAX DISPLAY

Press the MODE button to display the min/max temperatures recorded since last time they were reset. Press the up or down arrow keys to see the maximum and minimum recorded temperatures. Press MODE while a MAX or MIN is being displayed to clear the settings to the current temperatures, you will hear 2 beeps when it is cleared.

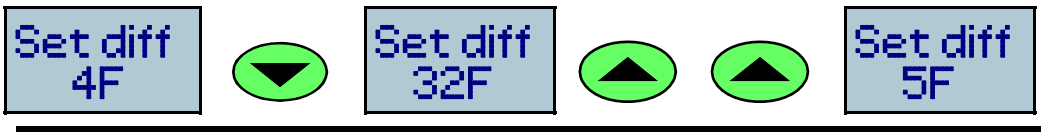
TEMPERATURE DISPLAY OPTION

Press the MODE button several times to access this mode. Temperatures can be displayed in degrees Fahrenheit or Celsius. Select Fahrenheit with the up arrow or Celsius with the down arrow. Temperatures below 0°F will cause a "NO SNSR" display and the unit will beep every 5 to 10 seconds, this is normal.



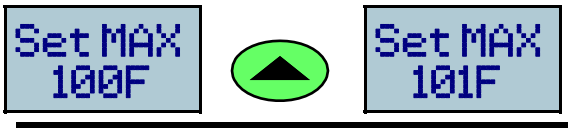
SET DIFFERENTIAL

Use the arrow keys to adjust the Maximum temperature from 4°F to 32°F (2° C to 16° C). Pressing the down arrow key at 4°F (2°C) will roll the display around 32°F (16° C). Similarly, pressing the up arrow at 32°F (16° C) will roll over to 4° (2°C). Note that while setting in Celsius mode, you will need to press the arrow keys more than once to change the setting.



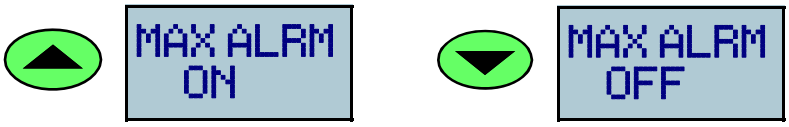
SET MAXIMUM STORAGE TEMPERATURE

Use the arrow keys to adjust the MAX temperature from 100°F (37°C) to 200°F (93°C). The temperature will roll around from 200°F (93°C)to 100°F (37°C) and the converse. Note that while setting in Celsius mode, you will need to press the arrow keys more than once to change the setting.



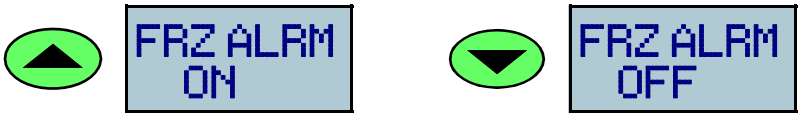
SET MAX TEMP ALARM

The up arrow key activates the alarm, while the down arrow key disables it. The alarm will beep every 5 seconds while the storage temperature is above the MAX set point.



SET FREEZE ALARM

The up arrow key activates the alarm, while the down arrow key disables it. This alarm will beep every 5 seconds while the storage temperature is below 35F.



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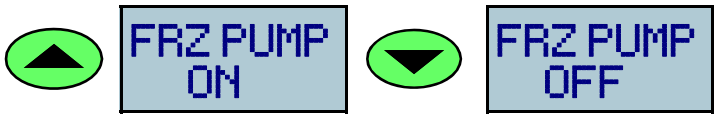
Solar Differential Temperature Controller
Model DTC-D

SET FREEZE PROTECTION PUMPING

Press the mode button several times to access the set max temp alarm mode. The up arrow key activates the alarm, while the down arrow key disables it. When enabled, the pump will activate if the collector temperature falls beow the freeze setpoint (see below) and will run until the temperature rises back above that setting. Note that this mode requires a battery or consistent DC power source. It will not protect collectors from freezing when the pump is powered from solar power alone. Use with caution.



SET FREEZE PROTECTION TEMPERATURE

Press the mode button several times to access the set freeze protection mode. Use the arrow keys to adjust the Diferential temperature from 1°F to 36°F, the default is 34F. This mode requires a battery or consistent DC power source. It will not protect collectors from freezing when the pump is powered from solar power alone.

In warm climates with plain water systems do not set this below 34F. In northern climates that use an antifreeze mixture in the collectors this set point can be adjusted to account for the antifreeze mixture rating. A low ratio of antifreeze to water will require a higher set point. Refer to the antifreeze maunuacturers specifications to deterine the level of freeze protection offered for your ratio, then set this at least 2F higher than that.

The settings will roll-over at the extremes. Pressing the down button will roll over from 1F to 36F as below.

If Freeze protection pumping is activated and the collector temperature falls below the set point the display will show:

If the freeze alarm AND freeze pump modes are active the display will alternate between these 2 screens while beeping every 5 seconds

PUMP MANUAL OVERRIDE

The pump can be overridden to be ON full-time or OFF. Press and hold the MODE button for 5 seconds to turn the pump off, the display will show PUMP OFF and will not show current temperatures. Wait for back light to go OFF before using the MODE button again. Hold the MODE button again for 5 seconds to set the PUMP ON. The pump will remain on and the display will not show current temperatures. Holding the mode button again for 5 seconds will select AUTO mode, and normal operation will resume after several seconds.

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Model DTC-D

FACTORY DEFAULT SETTINGS *(all settings are retained in permanent memory)*

- Temperatures displayed in Fahrenheit
- Differential temperature 4°F.
- Maximum temperature 180°F.
- Max alarm off.
- Freeze alarm off.
- Freeze pumping mode off.
- Freeze protection temperature 34F.

ALARM MODES

If the maximum temperature set point has been exceeded and the alarm has been enabled. The controller will beep every 5 seconds and show a MAX WARN briefly, and reverts to normal temperature display mode. Similarly the freeze warning will beep every 5 seconds and display FREEZING below the collector temperature.

If a sensor is removed, the screen will show a warning. The words NO SENSOR will alternate with a zero display on the line indicating which sensor is disconnected. In the example below, the collector sensor is disconnected or has open wiring in the circuit. If BOTH sensors are disconnected both readings will show as zero. Shorted sensor wires will show a value of over 2000

DETERMINING THE REQUIRED DIFFERENTIAL SET POINT

Use this procedure to determine the differential setpoint required to account for the heat loss in the plumbing from the collectors to the storage tank. Set the differential to 4F (the minimum). Then move the storage sensor to a section of pipe just before the heat exchanger. Wrap the sensor with insulation to protect it from ambient readings and wait for the collector reading to stabilize — about 10 minutes. Do this on a late fall or early spring day during daylight hours, the difference between the temperatures will be the differential temperature that you need to use. You can add a few degrees to allow for extreme winter temperatures and to ensure that the hot water entering the tank is always hotter than the current tank temperature.

DETERMINING THE MAXIMUM STORAGE TEMPERATURE

While the maximum storage tank temperature can be set as high as 200°F, this is not recommended since pressure/temperature relief valves are designed to open at 200°F. A typical setpoint would be 180°F. If you are using domestic water directly from the solar storage tank with no subsequent backup or tempering, you would want to set this temperature at or below 130°F to prevent scalding.

INTERNAL BATTERY

The controller has an internal 4.8 Volt battery consisting of four NiMH AAA rechargeable cells. The battery operates the controller in the absence of solar power to maintain the display and record maximum and minimum temperatures. The controller uses a small amount of power from the solar panel to charge these batteries during daylight hours — even on overcast days. The battery does not power the pump. The batteries should last for many years, however, should they need replacing, simply remove the front cover and install new AAA nickel metal hydride (NiMH) batteries . Do NOT use nickel cadmium (NiCad) or non-rechargeable Alkaline batteries. Please be sure to recycle the used batteries, find a drop-off location using: www.call2recycle.org

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SPECIFICATIONS

- **Operates from 0 to 30 Volts DC. Do not exceed 30 Volts!**
- **Uses standard 10K NTC thermistor sensors**
- **Adjustable differential 4-32°F (4 to 16° C)**
- **Adjustable max shut off 100-200°F (37 to 93°C)**
- **Adjustable freeze protection 1-36F (-17 to 2°C)**
- **Green LED indicator for PUMP operation**
- **Digital temperature display accurate to 1°F (2°C)**
- **All settings are maintained in permanent flash memory**
- **Switching capacity 6 Amps max (72 Watts at 12 Volts)**
- **Replaceable 6 Amp 3AG type fuse**
- **Built in surge protection**
- **Ambient operating temperature (0-160°F (-18-70°C)**

Internal 4.8V battery (4 AAA NiMH) operates device for up to 3 days without solar power

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TROUBLESHOOTING

Dim or blank display:

- If the display characters appear dim and the backlight does not seem bright, the internal batteries may be low due to a lack of solar exposure, this can be normal after extended periods (more than a week) of heavy overcast.
- Internal batteries may have died or have become disconnected. Remove the cover and test battery voltage. Each battery should read at least 1.2 Volts - up to 1.4 Volts, they should be considered dead if they are below .8 Volts. Replace with 4 new AAA nickel metal hydride batteries as needed. Do not mix old and new batteries or battery types. Do NOT use alkaline or NiCad batteries!
- The display is blank, shows filled black rectangles or jumbled text. Disconnect power, remove the cover, remove a battery for several seconds then replace it. If the display looks normal, consider replacing the batteries as they may be worn out.

Pump does not run:

- Confirm there is that DC power is present at the POWER terminals or sun on the PV panel that powers the system. Check power wiring. Remove the cover and check the internal fuse.
- If the green PUMP indicator lights, then check pump wiring and look for an open circuit.
- Try activating the pump using the manual override (press and hold the MODE button for 5 seconds twice). If the pump runs — look for wiring problems with the sensors. Open circuits to the sensor will be reported as above, shorted wiring will show a temperature over 2000F.
- Check the wiring and the polarity of the wiring to the pump.
- Ensure that the collector temperature is in fact, above the storage tank temperature by the number of degrees set in the differential setting. Review the differential setting.

Pump does not stop:

- Confirm that the collector is not hotter than the storage tank. Try shutting off the pump, using the manual override (press and hold the MODE button for 5 seconds). If it does not stop, the internal switching circuit may have failed, contact the factory for a return authorization or warranty repair.

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Sensor location

On **single pumped systems** (where the heat exchanger is inside the storage tank) the **collector sensor** should be mounted to the pipe with a pipe clamp within 6" of the exit at top of the collector. Wrap insulation around the pipe/sensor and protect from weather and ambielt temperatures. Insulation must be rated for high temperatures. Rubitex or other boiler insulation should be used and can be wrapped in aluminum tape or covered with split ABS pipe that is secured with tape or cable ties.

On **double pumped systems** where one pump circulates from the collector to an external heat exchanger, and another pump circulates from heat exchanger to storage, the **collector sensor** should be attached to the pipe that comes from the collectors about 2-3 feet before it enters the heat exchanger. The DTC-D should then be used to switch the secondary pump. The primary pump should be hard wired to a **separate** solar panel to ensure it always circulates with solar exposure. *If the system is DC powered (not PV) then BOTH pumps should be switched and the collector sensor should be placed per single pumped instructions above. This allows stored heat to warm the collectors*

The **storage sensor** should be located where it measures the average temperature of the stored water. If you can access the surface of the tank, then attach the sensor to the tank wall about 1/3 from the bottom.

If the sensor wiring is more than 6 feet long and passes near any AC wiring, the wires should be twisted. This prevents AC interference from affecting the sensor readings. All connections must be soldered and well insulated using heat shrink tubing to prevent corrosion Use standard 10K NTC sensors.

The DTC-D can be used with drain back systems, but an external relay is required to switch the higher powered pumps in these systems, see below.

HIGH POWER PUMPS

For larger pumps that exceed the 6 Amp capacity of the DTC-D, an external **solid state relay** is required (available from ARTTEC Solar). Mechanical relays should **not** be used in PV powered applications as they will not turn on at the lower voltages put out by the solar panel. Mechanical relays may be used with battery powered systems.

SIZING A PV PANEL

In latitudes above 30 degrees north (or below 30 south in the southern hemisphere) it is recommended that you use a solar panel with double the Watt rating of the pump(s) you are using. For instance use a 20 Watt PV panel with a 10 Watt pump. In tropical latitudes, you will have sufficient sun to use a 10 Watt PV with a 10 Watt pump.

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Model DTC-D

Temperature to Ohms chart for 10K NTC sensors

F	C	Ohms	F	C	Ohms	F	C	Ohms	F	C	Ohms	F	C	Ohms
1	-17.2	82719	51	10.6	19377	101	38.3	5697	151	66.1	2005	201	93.9	815
2	-16.7	80142	52	11.1	18870	102	38.9	5570	152	66.7	1966	202	94.4	802
3	-16.1	77656	53	11.7	18377	103	39.4	5446	153	67.2	1929	203	95.0	788
4	-15.6	75255	54	12.2	17899	104	40.0	5326	154	67.8	1892	204	95.6	775
5	-15.0	72937	55	12.8	17435	105	40.6	5208	155	68.3	1856	205	96.1	763
6	-14.4	70698	56	13.3	16985	106	41.1	5094	156	68.9	1821	206	96.7	750
7	-13.9	68535	57	13.9	16548	107	41.7	4982	157	69.4	1787	207	97.2	738
8	-13.3	66447	58	14.4	16123	108	42.2	4873	158	70.0	1753	208	97.8	726
9	-12.8	64428	59	15.0	15711	109	42.8	4767	159	70.6	1720	209	98.3	714
10	-12.2	62479	60	15.6	15310	110	43.3	4664	160	71.1	1688	210	98.9	702
11	-11.7	60595	61	16.1	14921	111	43.9	4563	161	71.7	1654	211	99.4	691
12	-11.1	58774	62	16.7	14543	112	44.4	4464	162	72.2	1626	212	100.0	680
13	-10.6	57014	63	17.2	14176	113	45.0	4368	163	72.8	1596	213	100.6	669
14	-10.0	55313	64	17.8	13820	114	45.6	4274	164	73.3	1567	214	101.1	658
15	-9.4	53669	65	18.3	13473	115	46.1	4183	165	73.9	1538	215	101.7	648
16	-8.9	52078	66	18.9	13136	116	46.7	4094	166	74.4	1509	216	102.2	637
17	-8.3	50541	67	19.4	12809	117	47.2	4007	167	75.0	1482	217	102.8	627
18	-7.8	49045	68	20.0	12491	118	47.8	3922	168	75.6	1455	218	103.3	617
19	-7.2	47616	69	20.6	12182	119	48.3	3839	169	76.1	1428	219	103.9	607
20	-6.7	46225	70	21.1	11882	120	48.9	3758	170	76.7	1402	220	104.4	598
21	-6.1	44879	71	21.7	11589	121	49.4	3679	171	77.2	1377	221	105.0	588
22	-5.6	43577	72	22.2	11305	122	50.0	3602	172	77.8	1352	222	105.6	579
23	-5.0	42318	73	22.8	11029	123	50.6	3527	173	78.3	1328	223	106.1	570
24	-4.4	41099	74	23.3	10761	124	51.1	3458	174	78.9	1304	224	106.7	561
25	-3.9	39919	75	23.9	10500	125	51.7	3382	175	79.4	1281	225	107.2	553
26	-3.3	38777	76	24.4	10246	126	52.2	3312	176	80.0	1258	226	107.8	544
27	-2.8	37671	77	25.0	9999	127	52.8	3244	177	80.6	1235	227	108.3	536
28	-2.2	36601	78	25.6	9758	128	53.3	3177	178	81.1	1213	228	108.9	527
29	-1.7	35565	79	26.1	9525	129	53.9	3112	179	81.7	1192	229	109.4	519
30	-1.1	34561	80	26.7	9297	130	54.4	3049	180	82.2	1171	230	110.0	511
31	-0.6	33590	81	27.2	9076	131	55.0	2987	181	82.8	1150	231	110.6	503
32	0.0	32648	82	27.8	8861	132	55.6	2926	182	83.3	1130	232	111.1	496
33	0.6	31737	83	28.3	8651	133	56.1	2867	183	83.9	1110	233	111.7	488
34	1.1	30857	84	28.9	8447	134	56.7	2809	184	84.4	1091	234	112.2	481
35	1.7	29998	85	29.4	8249	135	57.2	2752	185	85.0	1072	235	112.8	473
36	2.2	29169	86	30.0	8056	136	57.8	2697	186	85.6	1054	236	113.3	466
37	2.8	28365	87	30.6	7867	137	58.3	2643	187	86.1	1035	237	113.9	459
38	3.3	27587	88	31.1	7684	138	58.9	2591	188	86.7	1017	238	114.4	452
39	3.9	26832	89	31.7	7506	139	59.4	2539	189	87.2	1000	239	115.0	445
40	4.4	26100	90	32.2	7333	140	60.0	2489	190	87.8	983	240	115.6	439
41	5.0	25391	91	32.8	7164	141	60.6	2440	191	88.3	966	241	116.1	432
42	5.6	24704	92	33.3	6999	142	61.1	2392	192	88.9	950	242	116.7	426
43	6.1	24037	93	33.9	6839	143	61.7	2345	193	89.4	933	243	117.2	420
44	6.7	23391	94	34.4	6683	144	62.2	2299	194	90.0	918	244	117.8	413
45	7.2	22764	95	35.0	6530	145	62.8	2254	195	90.6	902	245	118.3	407
46	7.8	22156	96	35.6	6382	146	63.3	2210	196	91.1	887	246	118.9	401
47	8.3	21566	97	36.1	6238	147	63.9	2167	197	91.7	872	247	119.4	395
48	8.9	20993	98	36.7	6097	148	64.4	2125	198	92.2	857	248	120.0	390
49	9.4	20438	99	37.2	5960	149	65.0	2084	199	92.8	843	249	120.6	384
50	10.0	19900	100	37.8	5827	150	65.6	2044	200	93.3	829			

This chart is provided as an aid in troubleshooting sensor wiring.

NOTE: These readings are for the 1% tolerance probes supplied by ART TEC, other probes may vary .

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Warranty

ART TEC LIMITED FIVE-YEAR WARRANTY

ALL returns must be authorized before returning products to ART TEC. Items must be returned in their original condition, see below.

ART TEC reserves the right to repair or replace the returned product. ART TEC will pay for return shipping only, see below.

Returns for credit will be subject to a 20% restocking fee.

1. ART TEC LLC warrants its DTC line of controllers for a period of five (5) years from the date of purchase. This warranty is valid against defects in materials and workmanship for a five (5) year warranty period. It is not valid against defects resulting from, but not limited to:

A. Misuse and/or abuse, neglect, or accident.
B. Exceeding the unit's design limits.
C. Improper installation, including, but not limited to, improper environmental protection, and improper hook-up.
D. Acts of God, including lightning, floods, earthquakes, fire.
E. Damage in handling, including damage encountered during shipment.

2. This warranty shall be considered void if the warranted product is in anyway altered. The warranty will be void if the unit's serial number is in any way removed, altered, replaced, defaced, or rendered illegible.

3. The term of this warranty does not apply to equipment where another manufacturers' warranty is available. An example of such equipment may be, but is not limited to, an electronic enclosure. The time limit for this warranty may be for less than the limited warranty.

4. ART TEC cannot assume responsibility for any damages to any system components used in conjunction with ART TEC LLC products nor for claims for persona injury or property damage resulting from the use of ART TEC LLC products or the improper operation thereof or consequential damages arising from the products or use of the products.

5. ART TEC LLC cannot guarantee compatibility of its products with other components used in conjunction with ART TEC LLC products, including, but not limited to, solar modules, batteries, and external power sources or such loads as pumps, relays, blowers and other loads.

6. Warranty repair and/or evaluation will be provided only at the Woolwich, Maine facility of ART TEC LLC. Units for such repair and/or evaluation must be returned freight prepaid to ART TEC LLC with a written description of any apparent defects. DO NOT return any product without explicit approval from ART TEC LLC. ART TEC LLC will not be required at any time to visit the installation site wherein ART TEC LLC 's products are subject to warranty repair and/or evaluation.

7. Only ART TEC LLC is authorized to repair any of its products, and they reserve the right to repair or replace any units returned for warranty repair. The party returning unit for repair is responsible for proper packaging and for shipping and insurance charges, as well as any other charges encountered, in shipping to ART TEC LLC.

8. This warranty supersedes all other warranties and may only be modified by ART TEC LLC.