Dankoff LCB™
Solar Pump & Fan Controller

INSTRUCTIONS
For INSTALLATION and OPERATION

Model DL-8B (8 amp, 12/24V) Item ISS-11065

Model DL-16B (16 amp, 12/24V) Item ISS-11066

Model DL-10B (10 amp, 48V) Item ISS-11067

CUSTOM Models Please enter: ____ amp, ____V

Version 2.2 March 2010

CAUTION! READ ALL INSTRUCTIONS PRIOR TO INSTALLING OR USING THIS EQUIPMENT

Introduction "LCB" stands for *Linear Current Booster*. Its purpose is to couple a solar photovoltaic (PV) array to a DC motor, without the use of batteries. The LCB greatly increases motor performance, especially under low-light conditions and during startup. It is like shifting the gears in a vehicle, using "low gear" (reduced voltage / boosted current) to start the pump, and to prevent stalling in low light. It moves continuously toward "high gear" to maximize the performance whenever possible. *Maximum Power Point Tracking* (MPPT) refines this process by "fine tuning" the power draw from the PV array as sun and temperature vary. The LCB also protects the motor (and pump) by limiting the voltage to the motor, to prevent over-speed.

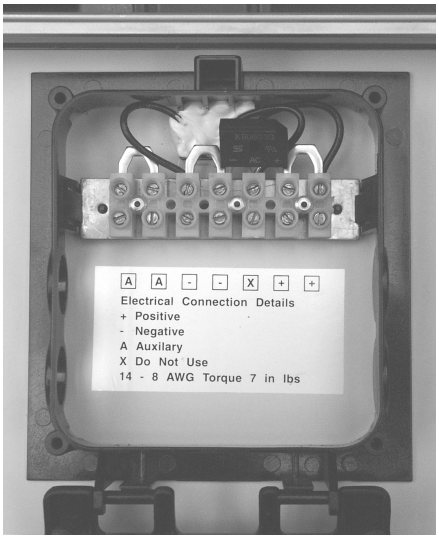
The *Dankoff LCB™* is a general-purpose unit, designed to work with a wide variety of solar pumps and other applications that use brush-type DC motors. For simplicity, we refer to your application simply as "pump", although yours may be a fan, blower, or even a small solar car or boat.

Dankoff LCB™ represents a significant improvement over LCBs of the past, especially this new "B" series. For more details, refer to the specification sheet attached.

INSTALLATION

WARNING The photovoltaic solar array generates hazardous voltages. For example, a 48 Volt (nominal) array can generate nearly 100 volts when disconnected from load. A short circuit or loose connection will produce an arc that can cause serious burns. All wiring must be done by qualified personnel, in compliance with local, state, and national electrical codes.

The solar array can produce hazardous voltage even under low light exposure. To prevent shock hazard while wiring the array, leave one or more wires disconnected or cover it with opaque material.



LCB LOCATION Install the LCB in the shade of the mid-day sun, to prevent excessive heat. Make a sheet-metal shade if necessary. If the pump must be located a long distance from the PV array, the LCB should be installed near the pump. This will minimize wire losses.

PV ARRAY LOCATION Sunlight is the "fuel" that drives a solar pump. Full solar exposure of the array is critical for performance. **Shading even a small portion of a PV array may cause the pump to stop completely.** Choose a location for the solar array that has unrestricted sun exposure through the day and through the year. Place the bottom edge of the array at least 2 feet (.6 m) above ground to clear rain spatter, growing vegetation and snow. Keep in mind that trees and plants will grow taller in the coming years.

PV ARRAY SIZING To assure full pump performance and good starting in low light conditions, the PV array must be rated for power output (watts) at least 20% greater than the power requirement of the pump. Refer to the specifications for your pump. Further over-sizing the PV array will improve low light performance (only) and will not damage the system. Up to 2X oversize is acceptable.

PV ARRAY VOLTAGE (12/24V models only) The array can be 12, 24 or 36V, to match or step down to a 12 or 24V pump. Using a higher array voltage reduces the wire size requirement exponentially. If you have a long wire run, place the controller at the pump so the long run is at the higher voltage. Input and output voltages are selected by a DIP switch on the circuit board, illustrated below.

PV ARRAY CONFIGURATION There are several configurations of PV modules used for solar pumps (wired in series, parallel, or both). Ask your system designer if you need assistance. **CAUTION Most new modules larger than 100 watts are 24V nominal, not to be confused with 12V modules of the past.**

CHOOSE AND INSTALL THE CORRECT FUSE IN THE LCB
WARNING - The fuse supplied with your LCB may NOT be the right one for your application. You may need to replace it with one of lower amperage rating, as required by the pump manufacturer. Failure to do so may void the warranty of your pump.

The *Dankoff LCB* has an internal fuse of type ATC or ATO, mounted on the circuit board. This is a common automotive plug fuse that comes in various amp ratings. Replacements are available from local automotive suppliers. These have slow-blow (time-delay) action that is appropriate for motor protection.

The fuse is in the OUTPUT circuit. It protects the LCB, AND your pump motor, AND your wiring, against overload current. Overload can occur from a wiring fault, a motor fault, or a mechanical problem that causes the motor to work too hard or to stall.

When the pump manufacturer requires that a fuse be installed in the supply circuit, the fuse in the LCB can meet this requirement if it is chosen properly. Often, the motor is rated for a lower current than the LCB. It is then necessary to replace the original fuse with one of a lower amp rating as advised by the pump manufacturer.

To determine the required fuse rating, follow the pump manufacturer recommendations, or multiply the FULL LOAD (MAXIMUM) AMPS of the pump by 1.15. Example: if the FULL LOAD AMPS of a pump is 4 amps, the fuse rating should be **(4 amps X 1.15 = 4.6 amps)**. Use the closest standard fuse value—in this case **5 amps**. **I**f a larger fuse was supplied with your controller **discard the larger fuse!** Keep spare fuses (of proper rating) inside the LCB enclosure in case of a pump or wiring fault.

WARNING Do NOT install a fuse with amp rating greater than the one originally supplied with your LCB. To do so will void the LCB warranty.
Model DL- 8B 10 amp maximum
Model DL-16B 20 amp maximum
Model DL-10B 15 amp maximum

GROUNDING AND LIGHTNING PROTECTION

WARNING Failure to install and connect an effective grounding system will greatly increase the risk of lightning damage and will void your warranty. We suggest you wire the grounding system FIRST so it is not overlooked. The concrete footer of a ground or pole mounted array will NOT provide adequate electrical grounding.

Surges induced by lightning are one of the most common causes of failures in solar pump systems. Damaging surges can be induced from lightning that strikes a long distance from the system, or even between clouds. Absolute protection is not possible, but you will greatly minimize the risk if you follow these instructions.

Earth ground Provide a good earth ground to the controller enclosure and PV panels. Proper grounding provides a discharge path for induced power surges from nearby lightning strikes. It also discharges accumulated charge potential which greatly reduces the chance of a direct lightning strike. A good ground connection requires the use of several copper clad ground rods driven into the earth a minimum of 6' apart and tied together by #6 AWG (American Wire Gauge) bare copper wire. The bare copper wire should also be buried. All connections must be mechanically tight and use compatible, non-corroding materials.

Bonding and grounding Bond (interconnect) all the metal structural components and electrical enclosures Interconnect the PV module (solar panel) frames, the mounting rack, and the ground terminals of the disconnect switch and the controller, using wire of minimum size #8 ($6mm^2$), and run the wire to an earth connection.

CAUTION Connect the earth ground to the ground terminal in the LCB but NOT to any power connections. Keeping the power circuits ungrounded provides superior resistance to surges induced by lightning. (Note: If a local electrical inspector requires you to ground one side of the power, and will not allow a variance, connect pump negative to the ground terminal.)

Solar array wiring Avoid forming loops of wire. Bind the array wires close together, or use multi-wire cable. This helps induced voltages in each side of the circuit to equalize and cancel each other out.

Wire twisting for long runs Twisting wires together tends to equalize the voltage induced by lightning. It reduces the voltage differential between the wires. This reduces the probability of damage. This method is employed in telephone cable, and in many other applications. Some cables are made with twisted conductors. To twist wires yourself, you can alternate the direction of the twist about every 30 feet (10 m). This makes the job much easier.

WIRING The power terminals in the controller will accept wire sizes from #14 to #2 AWG. Sizing of the PV input and pump wiring is critical, and often larger than that used for AC circuits. Undersized wire will cause power loss and poor performance. To determine proper wire sizes, refer to the Universal Wire Sizing Chart at *www.innovativesolar.com*, or ask your system designer.

All wiring should be done through the conduit knockouts located on the bottom of the LCB enclosure. Use weatherproof conduit to protect wires from animals and other damage. Seal any unused holes or other openings with silicone or acrylic caulk, to protect the circuitry from dust, moisture, insects, etc.

CAUTION Observe correct polarity when wiring PV and Pump connections. If there is sunlight on the PV array, the PV LED should illuminate. If it does not, the polarity may be reversed. Correct it immediately.

A float switch may be located up to 2000 feet (650 m) from the controller, using #18 or larger wire. Connect it using suitable cable to the Float Switch terminals in the LCB. Never apply power to the Float Switch terminals.

CAUTION: Use twisted-pair, shielded cable, similar to that used for telephone cable, for the float switch circuit. This will greatly reduce the risk of damage to the LCB from surges induced by lightning or thunderstorm conditions. We recommend ***Float Switch Cable,* Innovative Solar Part# ISS-11008,** available from your supplier. It has a twisted pair and is shielded, UV-resistant, and rated for direct burial. Shielded cable has a metallic foil or braid surrounding the wires. **Ground the cable shield at the LCB only – NOT at the float switch.**

OPTION: FLOAT SWITCH SURGE SUPPRESSOR,
This device is recommended if your installation has more than 50 feet (15m) of wires to a float switch that are NOT shielded, twisted-pair cable as recommended. In case of nearby lightning, this will reduce the risk of damage to the pump controller. If the suppressor itself is damaged, the pump will probably still work, and the suppressor will be less costly to replace than the LCB. This is a small device that connects to the Float Switch terminals in the controller or in a junction box, and provides connections for the float switch cable.

VOLTAGE SELECTION (Models DL-8B and DL-16B only) Refer to the 4-position switch (SW-1) set-up chart. It is located inside the front cover of the controller, and is also reproduced here.

WARNING Set the voltage selection BEFORE applying power, or damage may result.

PV=12 VOLTS MOTOR=12 VOLTS	**PV=24 VOLTS MOTOR=12 VOLTS**	**PV=36 VOLTS MOTOR=12 VOLTS**	**PV=24 VOLTS MOTOR=24 VOLTS**	**PV=36 MOTOR=24 VOLTS**
0 ------ 1	0 ------ 1	0 ------ 1	0 ------- 1	0 ------ 1
P ------ 2	P ------ 2	P ------ 2	P ------ 2	P ------- 2
E ------ 3	E ------ 3	E ------ 3	E ------ 3	E ------ 3
N ------ 4	N ------ 4	N ------ 4	N ------ 4	N ------ 4
(AS SHIPPED)				

SW-1 selection switch setup chart

INPUT VOLTAGE SELECTION Set the PV input voltage setting to match the nominal input voltage. Positions 1 and 2 of SW-1 select the PV input voltage range of 12, 24 or and 36 volts. Installations that require the PV panels to be located several hundred feet from the controller should use 24 volt or 36 volt PV input. The higher PV input voltage allows for the use of smaller sized wire with minimum power loss. Refer to the PV wiring diagrams for 12, 24 and 36 volt PV wiring.

OUTPUT VOLTAGE SELECTION Select the proper voltage to match the pump. Refer to SW-1 set-up chart. Switch position 4 changes the output voltage from 12 volts to 24 volts. Set position 4 to the OPEN for 12 volt output and position 4 to not-open for 24 volt output.

FLOAT SWITCH The pump can be controlled by a float switch located in the water storage tank. Its purpose is to stop the pump when the tank is full, and restart it when the water drops to a preset level. The float switch circuit works with very low current, so it can use small wire. See WIRING above.

The float switch circuit uses reverse logic (when switch makes contact, pump stops). When the full-tank float switch is down, it OPENS the circuit and the pump will run. We recommend the ***Float Switch Kit*,bpart # *ISS-11003,*** for full-tank shutoff.

Float switch for dry-run protection If it is desirable to prevent the pump from running dry, a different float can be installed in the water source. *Float Switch, open-on-rise,* Dankoff Solar Item #10323.

If two float switches are to be used (one of each of the above), connect them both to the float switch terminals (parallel) in the LCB. If EITHER of them makes contact, the pump will stop.

SYSTEM OPERATION

Pump operation may be controlled by a float switch located in the water storage tank or by the manual slide switch (SW-2) located inside the controller.
Slide switch SW-2 selects:
OFF pump will not run
AUTO pump will be controlled by the float switch circuit
FLOAT BYPASS pump runs regardless of float switch status.

AUTOMATIC START AND RESTART When float switch is open and sufficient solar power is available, the pump will automatically start.

WARNING The pump may start without warning. Disconnect the PV array or set SW-2 to OFF prior to servicing the pump.

INDICATOR LIGHTS Two LED lights indicate the presence of PV voltage and pump output voltage. When the RED light is on, PV voltage supplied to the controller and the polarity of the PV voltage is correct. If the RED light is not on, the PV panels may be wired incorrectly or the PV wiring may be faulty. The YELLOW light indicates voltage supplied to the pump. If the YELLOW light is off when the pump should be on, the output fuse may be open (blown).

CONTROLLING FANS The controller works equally well with fans. Replace the Float Switch with a suitable thermostat switch if desired. When the thermostat switch is open the fan will run. To avoid excessive fan starting use a thermostat switch with sufficient differential between on and off temperatures.

MANUAL ON/OFF CONTROL An array disconnect switch can be used for manual on/off control. If it is desirable to switch the pump on/off from a distance, an ordinary manual switch can be connected to the FLOAT SWITCH terminals. When the switch is CLOSED ("on"), the pump will turn OFF.

TROUBLE SHOOTING

In case of trouble, refer to your pump instruction manual. If the problem is in the wiring or the LCB, simple voltage measurements may help you to locate it. You can do perform these tests with a simple "multi meter", available at a local electric supply or hardware or automotive store. Be sure the red test probe is plugged into VOLTS, not amps. Set the function selector to DC VOLTS.

NORMAL VOLTAGES

PV volts nominal	PV open circuit volts	PV input, pump ON	Volts at pump terminals
12	18-22	15-18	12V pump: 0-15
24	36-44	30-36	24V pump: 0-30
36	54-66	45-54	36V pump: 0-45
48	72-88	60-72	48V pump: 0-60

EXPLANATION

Volts nominal means the "name" of the voltage standard. The actual voltage varies.
PV open circuit volts is the voltage of the solar array when it is NOT connected or when the LCB is OFF (it is "idle"). This indicates whether the array is wired correctly.
PV input, pump ON should be nearly constant, regardless of variation of the sunlight. It tends to be lowest in hot weather.

Voltage at float switch terminals	switch open (pump ON)	5 to 8 Volts
	switch closed (pump OFF)	0 Volts

IF PUMP DOESN'T RUN

Loose connections are the most common cause of trouble. Pull on each connection to confirm that it is secure.

Indicator lights If the solar (PV) array is connected and exposed to sun, but the *PV* (red) light is OFF: Inspect PV array wiring. Measure "PV input" volts against the table above. Check that the polarity (+/-) is correct.

***PV* light ON but pump doesn't run** The pump may be wired incorrectly, or the fuse may be blown. Pull the fuse and inspect it visually. Look for a melted link in the fuse. See FUSE section above. Look for a fault in the pump mechanism or pump circuit. If the pump is a few years old, the motor brushes may be worn. Refer to your pump instruction manual, troubleshooting section.

Physical inspection Inspect the circuit board carefully for physical damage.

Lightning damage? If failure occurred around the time of a thunderstorm, it may be advisable to improve the earth grounding or other aspects of lightning protection, as described above.

Test your pump (motor device) with a battery To help determine if the problem is in the pump or the power system, you can disconnect the pump from the LCB and connect it to a battery to see if it will run. You can use a 12V battery even if the pump is 24V or 48V. It will simply run slower. If the pump doesn't run, and there is voltage at the LCB output, the problem is in the pump or its wiring.

WARNING Never replace the correct fuse with one of a higher AMP rating. To do so will void the warranty of the LCB and your pump.

WARRANTY

Dankoff LCB™ is warranted to be free from defects in material and workmanship for FIVE YEARS from date of purchase.

Failure to provide correct installation, operation, or care for the product, in accordance with the instruction manual, will void the warranty. Product liability, except where mandated by law, is limited to repair or replacement, at the discretion of the manufacture. The manufacturer is not responsible for the labor or other charges necessitated by the removal, transportation, or reinstallation of any defective product.

Warranty does not cover damage due to: Mishandling or abusive conditions; failure to protect unit from weather exposure; failure to protect from overheating due to sun exposure; failure to protect from salt spray or other corrosive factors, seal out insects, spiders or rodents, lightning, flood or other acts of nature, or failure of or inappropriate application of peripheral devices including lightning or surge protectors.

No specific claim of merchantability shall be assumed or implied beyond what is printed on the manufacturer's printed literature. No liability shall exist from circumstances arising from the inability to use the product, or its inappropriateness for any specific purpose. It is the user's responsibility to determine the suitability of the product for any particular use. In all cases, it shall be the responsibility of the customer to insure a safe installation in compliance with local, state and national electrical codes.