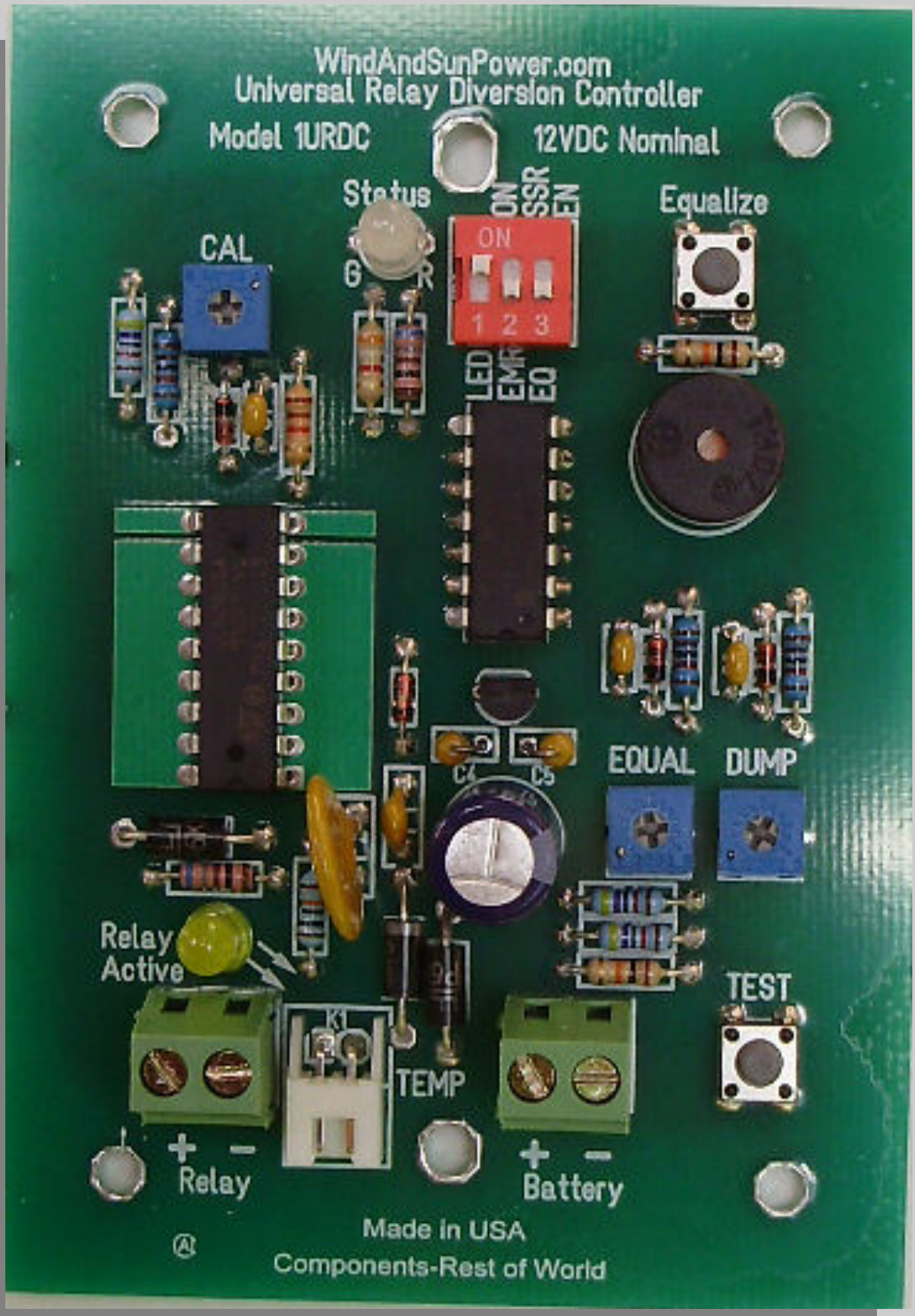
UNIVERSAL RELAY DIVERSION CHARGE CONTROLLER
MODEL 1URDC 12V (Board Version 4.2.X)
For both EMRs (ElectroMechanical Relays)
and SSRs (Solid State Relays)
For Wind, Solar and Hydro
(Manual Version 1.1.2)



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READ ALL INSTRUCTIONS CAREFULLY!!
CONTROLLERS OF THIS TYPE ARE MORE COMPLEX SETTING UP THAN YOUR ALL IN ONES!! YOU MUST CALCULATE THE MAXIMUM POWER YOUR SYSTEM CAN POTENTIALLY GENERATE AND THEN CALCULATE THE SIZE OF THE LOADS AND WIRES ACCORDINGLY FOR MAXIMUM SAFETY!!!
IF YOU HAVE ANY DOUBTS ABOUT YOUR ABILITIES TO PUT TOGETHER A SYSTEM OF THIS TYPE THEN DON'T DO IT!!
FIND AND/OR HIRE SOMEONE QUALIFIED WHO CAN!!

Introduction

These diversion controllers were brought about by there being no low cost expandable diversion controllers on the market that would maximize battery charge and life.

Months of testing and research both on these and other commercially available dump controllers, has proven that the On-Off algorithm using **EMR**s (**E**lectro**M**echanical **R**elays) in diversion/dump mode is seriously lacking. EMRs are slow (most can not be switched faster than 2 sec on, 2 sec off to prevent self destruction and contact bounce), this delay knocks the surface charge too low when switching a load on and off so that the battery cannot absorb enough energy to fully charge. This works fine however when disconnecting the charging source from the battery and letting the battery voltage drop naturally. The majority of wind and hydro generators cannot simply be disconnected from battery and allowed to free spin as this could cause them to over rev at high speeds and self destruct. Most SSRs (Solid State Relays) on the other hand can be switched at 20ms on and 20ms off or faster so as not to let the battery voltage drop too low. Thus allowing the batteries to absorb more energy, resulting in the batteries charging at a much higher rate and **SOC** (**S**tate **O**f **C**harge) which leads to a greatly extending battery life (batteries are the greatest consumable cost in renewable energy systems).

In the process of developing a effective charge algorithm for use with SSRs in which I call **ULFAPWMA** (**U**ltra **L**ow **F**requency **A**daptive **P**ulse **W**idth **M**odulation **A**lgorithm). I started seeing how many features and how much protection I could add and still keep them inexpensive. Also I have tried to make these as user friendly, adaptable and expandable as possible. These controllers are what **I WANTED** in a controller of this type and not the simple, barely adequate ones that were being offered on the market in this and higher price ranges.

I will try to keep this manual as simple and straight forward as possible as to not over complicate things for newbies.

This manual will probably evolve for some time so to keep cost down and prevent unnecessary waste, the latest version of this manual in PDF format is **Free** for **DOWNLOAD HERE at http://www.windandsunpower.com/Download/1URDC_V4_Manual.pdf**(just printout what you need) or a printed version is available for $3 USD from WindAndSunPower.com

Thanks,
Jeff

DESCRIPTION

The Universal Relay Diversion Controller/Regulator is a low cost Microprocessor controlled dump/on-off type controller designed for the **DIY** (**D**o **I**t **Y**ourselfer). It is designed to switch up to 6 conventional automotive style electromechanical relays (EMR) with up to 800ma total coil current draw with up to 240A power handling capability. Also unlike other controllers of this type of design, this will also control DC-DC Solid State Relays (SSR) in conventional (Dump) diversion mode or use a 2-Stage charge algorithm and a Equalization mode. It is theoretically able to switch up to 32 SSRs at 25ma each (untested). If using just 40 amp SSRs that adds up to a potential 1280A power handling capability.

To keep cost down, this controller was designed for the DIY (Do It Yourselfer) and is the **BOARD ONLY** and does not include an enclosure. It can be mounted directly on a wall in a area protected from the environment or in a **Optional** or **user supplied** enclosure.

FEATURES

- The ability to switch up to 6 Electromechanical or 32+ DC-DC Solid State Relays
- Conventional Electromechanical or Solid State Relays - Dump/Diversion/On-Off Modes
- 2-Stage - Dump/Diversion (Solid State Relays Only)
- Manual Equalization Mode (Solid State Relays Only)
- Extreme Low Power Consumption (≤ 6ma) in Standby Mode
- Accurate Battery Voltage Tracking
- User Settable Dump/Diversion/On-Off Voltage Set-point (13.1 to 15.1 Volts)
- User Settable Equalization Voltage Set-point (14.5 to 16.5 Volts) (Solid State Relays Only)
- **Optional** Temperature Compensation -5°F(-20°C) to 130°F(55°C)
- 800ma power handling
- The Ability to Divert/Dump 800ma Directly for Very Small Systems
- Self Resetting Resettable Fuses (Separate Power and Microcontroller Section Fuses)
- Multicolored LED Status Indicator with Off Switch for Lower Power Consumption
- LED Relay Power/Active Indicator
- Test Button
- Over Voltage Indication and Alarm (Discontinued on boards marked SV3.1 and up)
- Dead Battery Indication and Alarm
- Reverse Polarity Protection
- Over Voltage Protection
- Over Current Protection
- Transient/Lightning/Surge Protection

OPERATION

Basic operation principle is quite simple. The Microcontroller constantly monitors the battery voltage and temperature (if optional probe is connected). When battery voltage meets specific criteria, the Microcontroller activates or deactivates LEDs, buzzer and external relays. The temperature probe automatically raises or lowers the dump voltage setting dependent upon battery temperature.

MOUNTING

To keep cost down, this controller was designed for the **DIY** (**D**o **I**t **Y**ourselfer) and is the board only and does not include an enclosure. It can be mounted directly on a wall in a area protected from the environment or in a optional or user supplied enclosure.

This Board has been designed to fit the following inexpensive **BUD Industries** NEMA Enclosures:
NBF-32002 ABS Solid Door
NBF-32102 Indoor Version Solid Door
NBF-32202 Indoor Version Clear Door
NBF-32302 Outdoor Version Solid Door
NBF-32402 Outdoor Version Clear Door

The board does not generate much heat but it does generate some and the more relays, the more heat. Because heat sinking is incorporated into the board design and to prevent shorting, the board needs to mounted at least ¼ inch off the surface using some sort of standoffs.

With EMRs the controller and the relays can be mounted in the same enclosure if there is adequate room because EMRs generate little heat usually. However if you are using SSRs they can generate a lot of heat and the SSR heatsink assembly should be mounted in a well ventilated area on a metal surface in free air preferably or in a very well ventilated metal inclosure. The same goes for power resistors.

WIRING

If you look at the diagrams you can see the wiring is pretty straight forward. You should use 22 to 16 gauge AWG wire between the controller and from the controller to the relays. Keeping distances between components close as possible for maximum efficiency and accuracy. A pair of wires from the controller to the batteries and a pair of wires from the controller to the relays. The loads, fuses and wires from the relays to the loads and power sources to the batteries will need to be calculated for your systems maximum potential output.

Min. Copper Gauge	Max. Amperage	Min. Copper Gauge	Max. Amperage
18AWG	7.5A	**8AWG**	45A
16AWG	10A	**6AWG**	60A
14AWG	15A	**4AWG**	80A
12AWG	20A	**2AWG**	100A
10AWG	30A	**1AWG**	125A

Function Selection Switch

1. **LED** = **Status LED** - Top position **ON,** Bottom position **OFF**
2. **SSR** = **Relay type switch** - Top position **SSR** 2-Stage Mode (SSRs Only), Bottom position **EMR** On/Off Mode (EMRs or SSRs)
3. **EQ** = **Equalization Button** (SSR Mode Only) - Top position button is **Enabled,** Bottom is position button **Disabled**

RELAYS

This was designed to use up to 6 Automotive style EMRs (the ones you can find in auto parts stores for 3 to 5 dollars) or up to 32 DC-DC SSRs. Multiple relays need to be wired in parallel. This can be used with other types of NON-LATCHING EMRs with nominal **coil ratings of 12VDC, 800ma max and contacts MUST be rated above your battery bank voltage**. You will need to try them out to see if they will perform suitably. Dependent on the load, batteries and generator output, this controller can regulate the battery voltage to within ± .4% 0.062V on the average. Whereas using EMRs with On/Off type Diversion controllers, battery voltage can fluctuate up to a volt or even more. When using SSR's use DC-DC SSRs Only! SSRs are more costly and a bit more complicated. The main thing being is the need for adequate heat-sinking as they can get quite hot.

Diagrams 1. and 2. below are some examples of SSR Heatsinks.

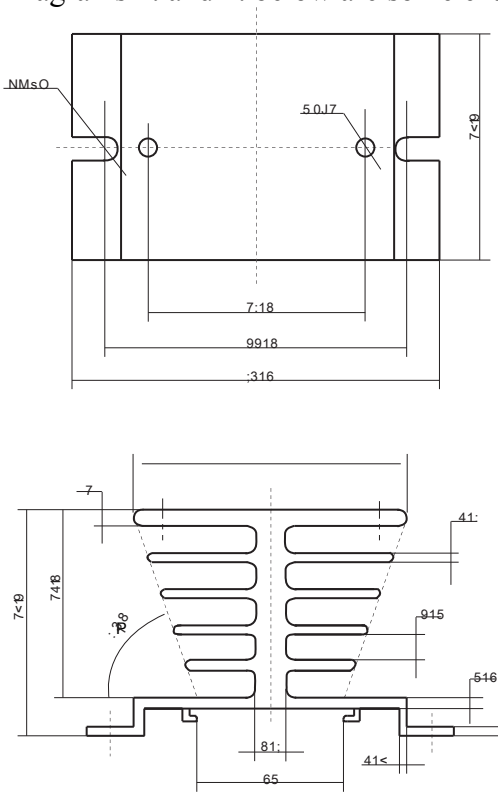


Diagram 1.
15A SSR Heatsink Example
Approximately 2”L x 2.5”W x 2”H

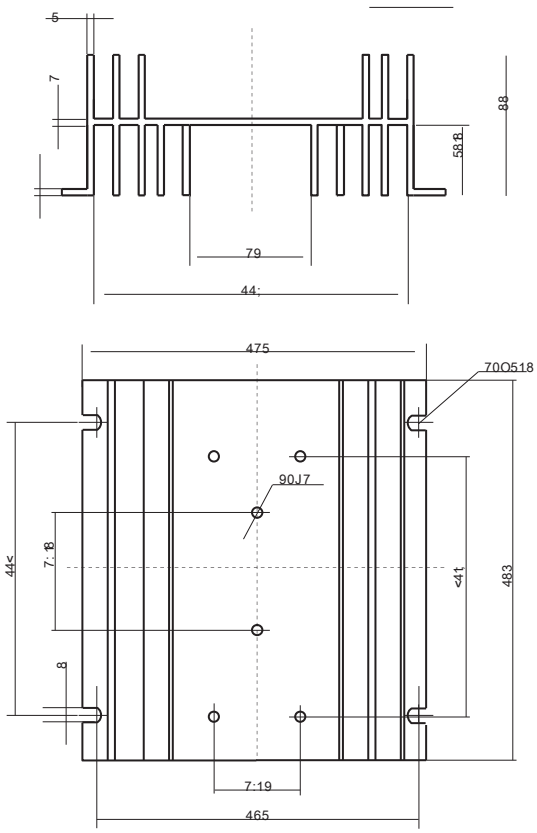


Diagram 2.
40A SSR Heatsink Example
Approximately 6”L x 5.5”W x 2”H

Here are some inexpensive 40A **DC-DC** SSR's tested:
SMUNGLE SG D2240D **BAD** – NO GOOD JUNK SSR (eBay)
Mager MGR-1 DD220D40 **GOOD** – Works well with 12V, marked 24-220VDC (eBay)

LOADS

You can buy resistive loads such as power resistors and DC water heating elements on many RE websites with the volts, amps and watts listed for them. Or to save money you can do the calculations yourself and purchase at a lower cost from electronic suppliers and/or surplus sellers. Also if your real handy you can build your own from junkyard parts.

Your Loads need to be at least 120% of the Maximum power that your system could potentially generate. To calculate you systems maximum watts simply multiply the maximum amperage your system can generate by your batteries maximum charge voltage V x I =W. If you are going to switch the source generator, you should use the maximum voltage and amperage that it can generate to calculate the size of your loads.

1. The Hard Way to Calculate Loads

The power dissipated by a linear resistor may be calculated from its resistance, and voltage or current. The formula is a combination of Ohm's law and Joule's laws:

$$P = V \cdot I = \frac{V^2}{R} = I^2 \cdot R$$

where **P** is the power in watts, **R** the resistance in ohms, **V** the voltage across the resistor, and **I** the current through it. This formula is applicable to devices whose resistance varies with current.

2. The Easy Way to Calculate Loads

Here's an assortment of online Voltage-Current-Resistance-Power calculators
OHMITE http://www.ohmite.com/ohmslaw.html
OPAMPLABS http://www.opamplabs.com/eirp.htm
the12volt.com http://www.the12volt.com/ohm/page2.asp

Here's some links on homemade/DIY Resistors/Loads **(I Accept No Responsibility For Any Information in any of these Documents, Use AT YOUR OWN RISK!)**
www.thebackshed.com/Windmill/articles/200wDumpLoad
www.thebackshed.com/Windmill/articles/BuildingEncapsulatedResistors

Resistive loads can get extremely **HOT,** hot enough to start a fire or cause severe burns so be sure to follow proper safety precautions, such as:

1. **Do Not** mount Power resistors directly to flammable materials.
2. **Do Not** put flammable materials on or in close proximity to Power resistors.
3. **Do** mount Power resistors to a metal surface/plate, preferable with stand offs between wall and resistor mounting plate for cooling.
4. **Do** mount Power resistors in a location where children, pets or yourself will not come into physical contact with them as they can get hot enough to cause severe burns. If necessary purchase or build a protective cage around them.
5. Lastly **Do Use Common Sense!**

TEMPERATURE COMPENSATION (With Optional Probe)

If your batteries are in a controlled environment with temperatures remaining between 70 and 90 degrees Fahrenheit temperature compensation is usually not necessary.

To connect your temperature compensation probe you simply just plug the connector into the socket marked **TEMP** on the PCB and slip the other end between two batteries or tape it to the side of one.

WARNING! This controller was designed primarily for Flooded Lead Acid batteries, if using this controller with Sealed, Gel Cell or other batteries, DO NOT use the temperature compensation option! At colder temperatures the battery voltage can rise high enough to damage and/or destroy the batteries!

Additionally most inverters have a 15V design limit. If you charge your batteries at higher voltages and/or your batteries get cold enough, then the temperature compensation can raise the battery voltage above this limit!

TEST BUTTON

Pressing the test button simulates an over voltage condition, activating red status LED, alarm buzzer and dump relay/'s. If equalization is in progress it cancels it out.

OVER VOLTAGE ALARM

(Discontinued on boards marked SV3.1 and up because of conflicts with Temperature Compensation)

The over voltage alarm is a feature I added to help detect relay, connection and load problems.

If the voltage rises .5 volts above any of the set points the Microcontroller activates the buzzer, turns the status LED Red, switches the relays on continuously until the battery voltage returns to normal operating parameters and then resets the system. If the temperature compensation probe is connected the Microcontroller automatically compensates the alarm setting for the increasing or decreasing of the dump set points.

This is not a fool proof solution but it can help in notifying you of possible relay failure if the relay latches open (if a relay latches closed it will eventually drain the batteries) , corroded or loose wire connections and undersized loads.

EQUALIZATION
(Solid State Relays in 2-Stage Mode Only)

Equalization mode is **Not** temperature compensated if you have the optional probe connected. A lot of small systems may not generate enough power to fully equalize the batteries. To equalize your FLA batteries (Follow Manufactures Recommendations! Check/Fill Battery water level Before and After!):

1. Disconnect/Turn Off (dependent upon device) any and all devices that cannot handle 15.5 and higher volts.
2. Make sure the EQ switch is enabled.
3. Push and hold the Equalize button until the Status LED flashes alternating Red and Green

Equalization mode will continue until 1 of 3 conditions are met:

1. The total time accumulated that the batteries are at between 15.3 and 15.5 (Adjustable) volts equals to approximately 2 hours.
2. It times out after approximately 48 hours if the batteries are not held at equalization voltages for 2 hours total.
3. The test button is pushed canceling equalization.

WARNING! This controller was designed primarily for Flooded Lead Acid batteries, if using this controller with Sealed, Gel Cell or other batteries Disable and DO NOT use the equalization option unless the manufacture says it is safe to do so! If so, Recalibrate the Equalization set-point at or below the battery manufactures specifications! Not following these precautions can cause the battery voltage will rise high enough to damage and/or destroy the batteries!

DUMP/DIVERT VOLTAGE and other SET-POINT ADJUSTMENTS

First off, **DO NOT adjust the calibration potentiometer (Marked CAL on the PCB)** as this is used to calibrate the Status LED and Internal set-points.

The controller is preset at 14.3 volts. This is a safe point for most batteries, it is low gassing and will charge most batteries to approximately 90 to 95 percent of their capacity. However this setting will **not** charge most FLA (Flooded Lead Acid) deep cycle batteries fully and the batteries maximum capacity will slowly drop lower with each subsequent charge. Check the battery manufactures recommended charge voltage which you can usually find on their website. Most FLA deep cycle batteries have a high daily charge voltage (currently TROJAN recommends 14.8 V daily charge and 15.5 V equalization charge). Both of which causes higher water loss (adding distilled water more frequently), and **VERY HIGH GASSING** which unless you have a proper ventilation system in place and follow proper safety practices can be **DANGEROUS!** If you can't meet these requirements leave the setting at 14.3V or lower (Set to 14.1V when using SSRs).

The 14.3 was settled on because most smaller systems are not generating all the time and it was the voltage that gave the highest charge capacity with low gassing for a 2-stage controller. There are so

many variations in systems and batteries it's imposable to come up with a perfect "**universal**" default dump setting. It is up to you, to decide on the best dump voltage for your system. This is why all good controllers have adjustable set points.

This could take some time. You will be adjusting the potentiometer marked **ABSORB DUMP** on the PCB.

1. If you have the optional temperature compensation probe, unplug it from the PCB.
2. Hook a accurate volt meter directly to your batteries.
3. Let the batteries fully charge to the current set-point and stabilize.
4. If lowering the set-point slowly turn counterclockwise until the battery voltage reaches the desired setting (If lowered to fast you could set off the over voltage alarm), let it stabilize and repeat up or down if necessary until your satisfied with the setting. If raising the set-point slowly turn clockwise until the yellow dump led goes out. Wait for the voltage to rise to the new set-point and stabilize, Check your volt meter to see if it dumps at the desired voltage. Repeat adjusting the pot up or down if necessary until your satisfied with the setting.
5. If you have the optional temperature compensation probe, plug it back in to the PCB.
6. Disconnect volt meter if you wish.

Note: If your using SSR's with the 2 stage setting and your constantly generating power with your batteries staying fully charged most of the time. You might want to set the dump voltage down closer to the manufactures recommended float voltage and equalize the batteries more often.

EQUALIZATION SET-POINT ADJUSTMENT

Follow the same procedures for setting the Equalization set-point except you must enter Equalization mode to do so The system must be able to bring the battery voltage up to the desired set-point and then you can turn the Equal adjustment down until the relays activate. Once the batteries are held at this level long enough to stabilize, recheck the voltage and adjust accordingly if necessary.

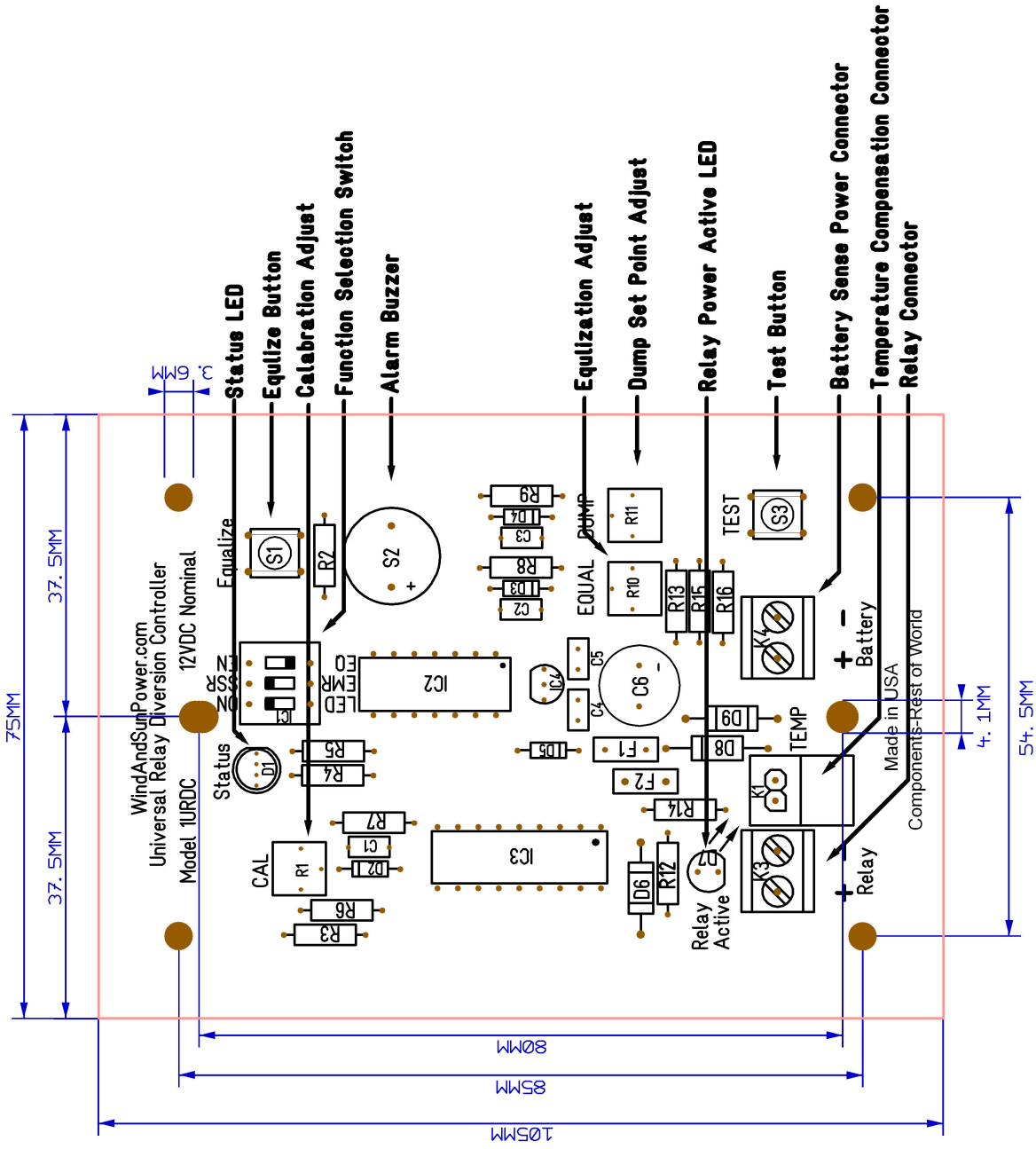
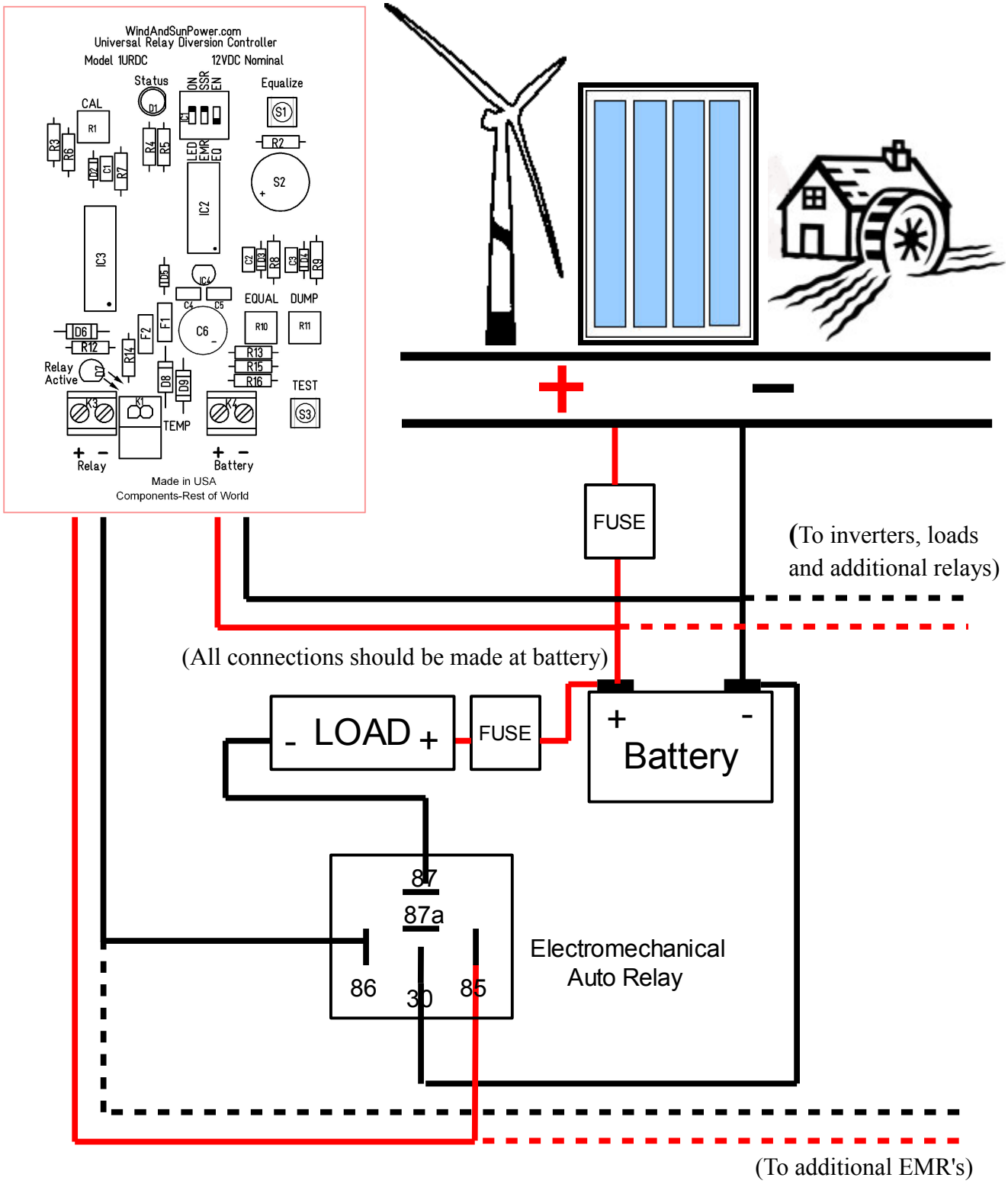

Status LED
Equlize Button
Calabration Adjust
Function Selection Switch
Alarm Buzzer
Equlization Adjust
Dump Set Point Adjust
Relay Power Active LED
Test Button
Battery Sense Power Connector
Temperature Compensation Connector
Relay Connector
WindAndSunPower.com
Universal Relay Diversion Controller
Model 1URDC
12VDC Nominal
Made in USA
Components-Rest of World
Battery
Relay
Status
Equalize
CAL
PUMP
EQUAL
TEST
TEMP
Relay Active
75MM
37.5MM
37.5MM
54.5MM
4.1MM
6MM
105MM
85MM
80MM

Diagram 3.

Wiring Diagram 1. ELECTROMECHANICAL RELAY (EMR) DIVERSION/DUMP MODE

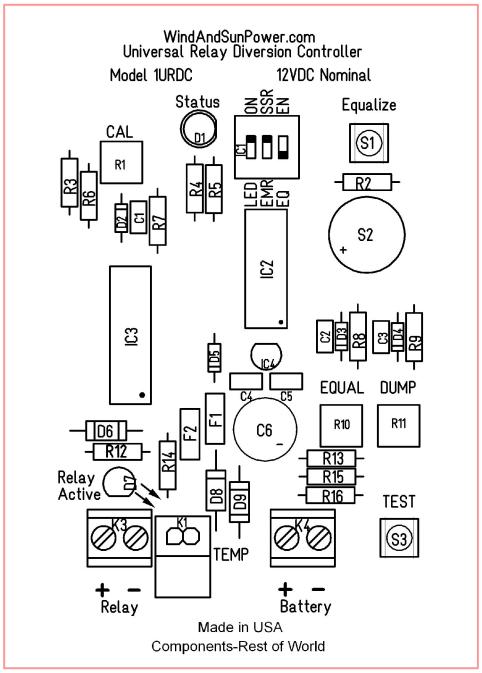
SOLAR YES (You can have all 3 sources connected to/charging)
WIND YES (the batteries at the same time in this configuration)
HYDRO YES

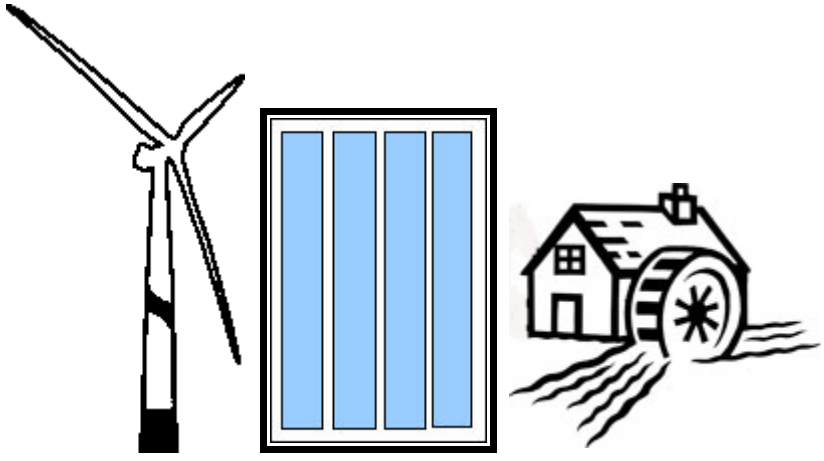


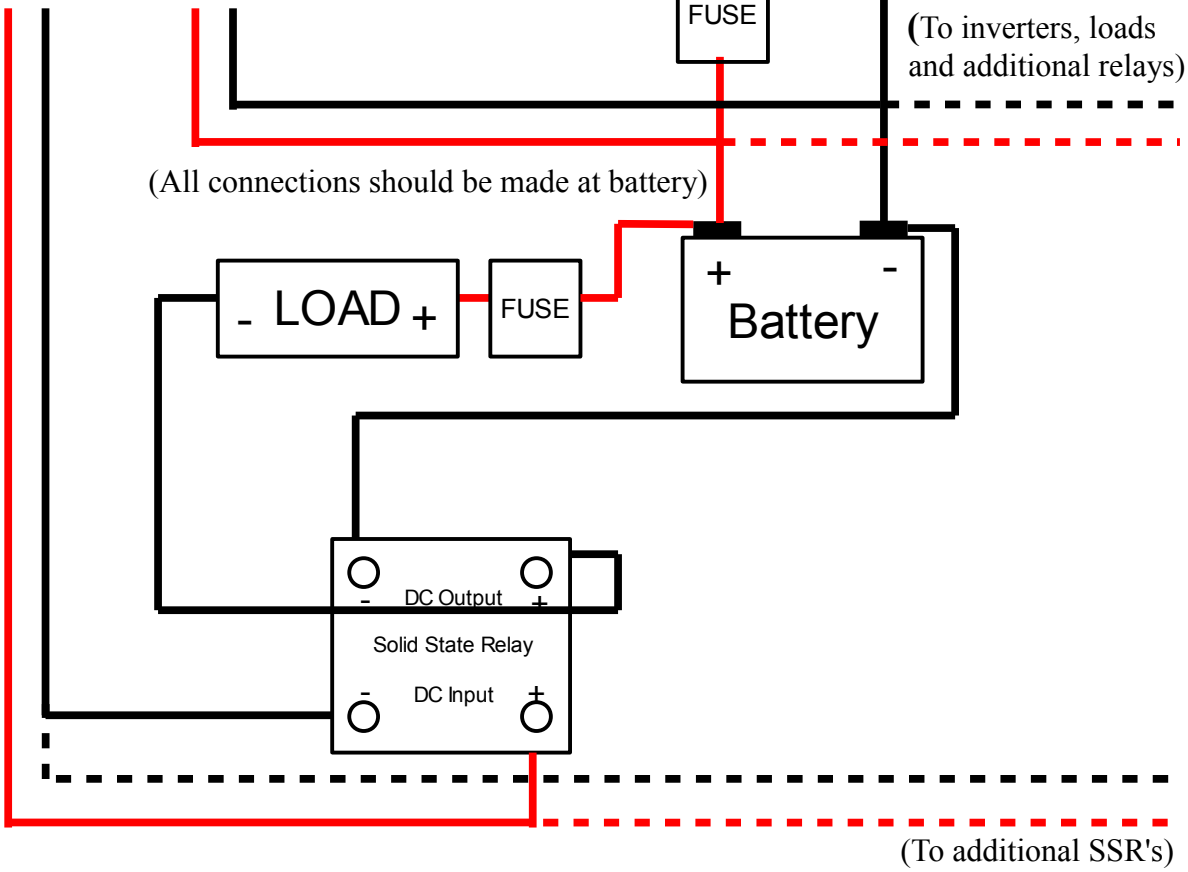
Wiring Diagram 2. SOLID STATE RELAY (SSR) DIVERSION/DUMP MODE

SOLAR YES
WIND YES
HYDRO YES

(You can have all 3 sources connected to/charging)
(the batteries at the same time in this configuration)

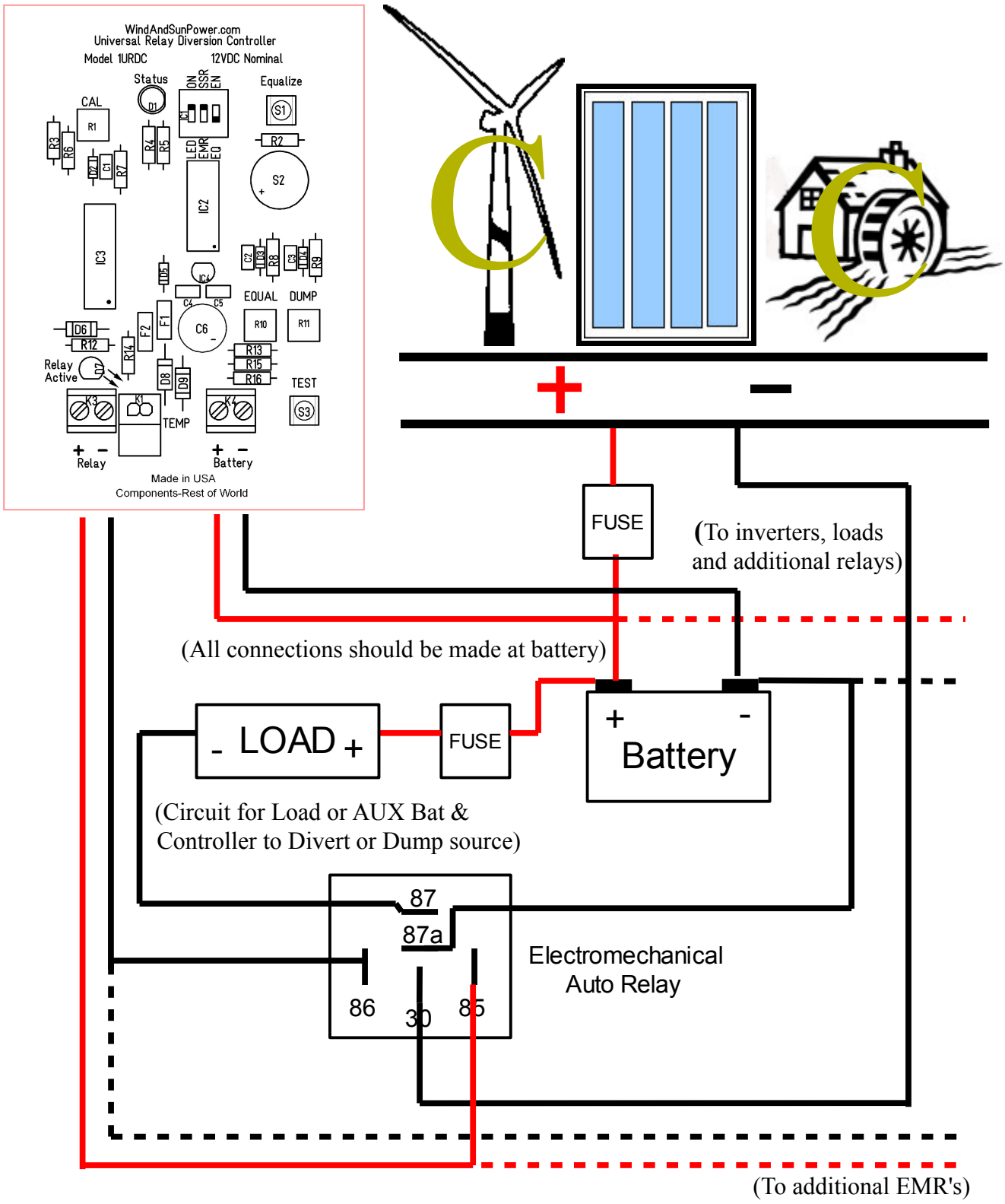






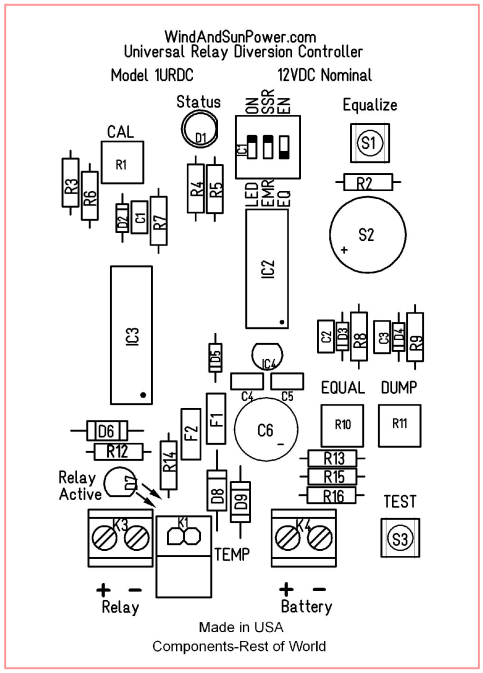
Wiring Diagram 3. ELECTROMECHANICAL RELAY (EMR)
ON-OFF DIVERSION/DUMP SOURCE MODE

SOLAR YES
WIND CAUTION (You can use this circuit but understand that by fully loading the generator)
HYDRO CAUTION (down, you could cause it to over heat and possibly result in damage to it)



Wiring Diagram 4. ELECTROMECHANICAL RELAY (EMR)
DISCONNECT or ON-OFF MODE

SOLAR YES
WIND NO! (You can NOT use this circuit for wind or hydro, because if-)
HYDRO NO! (you unload the generator it could over rev and self destruct)

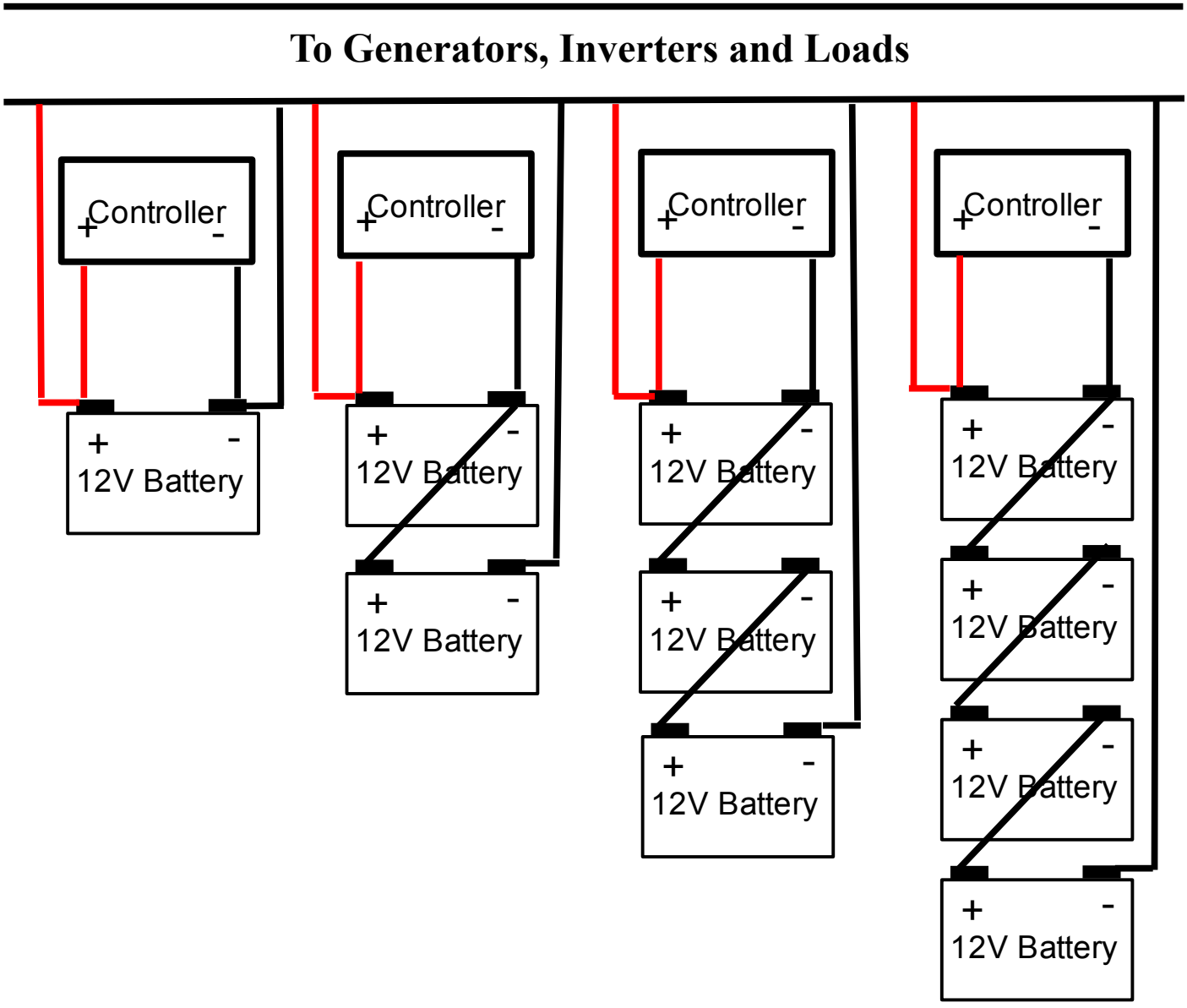


Wiring Diagram 5. Battery Wiring Diagrams for 12, 24, 36 and 48 Volt Systems

You simply hook the controller's "**Battery**" leads to a 12V **cell** in your 24, 36, 48, 60, etc. volt battery bank and you connect your properly configured loads, inverters and generators across the full voltage of your battery bank. **The relays Coil/Input needs to be 12V nominal, the Contacts/Output Needs to exceed the battery banks maximum voltage.** If your batteries are in good shape, all set points, temperature compensation, and LED indicator voltages are proportionally compensated. You just take the nominal system voltage and divide by 12, you the take the resulting answer and use it to multiply the set points and LED voltages.

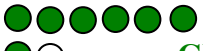
Examples 24v / 12v = 2 then 2 x 14.3v = 28.6v
48v / 12v = 4 then 4 x 14.3v = 57.2v

(Tested)	(Tested)	(UnTested)	(UnTested)
12 Volt System	**24 Volt System**	**36 Volt System**	**48 Volt System**
	Set Point & LED Voltages		
X1	**X 2**	**X 3**	**X 4**



LED FLASH LEGEND

Approximate State of charge at 80ºF (26.6ºC) and at rest for 6 hours or more.
(No Charging or Discharging of Batteries)
(LED SOC Generalized for FLA Deep-Cycle Batteries)

	**RED** LED **1** flash every 20 sec and alarm chirps at 10.5 volts or lower		
	**RED** LED **1** flash every 10 sec	11.35 volts or lower	0% state of charge
	**GREEN** LED **1** flash every 5 sec	11.36-11.65 volts	1 to 20% state of charge
	**GREEN** LED **2** flashes every 5 sec	11.66-11.95 volts	21 to 40% state of charge
	**GREEN** LED **3** flashes every 5 sec	11.96-12.25 volts	41 to 60% state of charge
	**GREEN** LED **4** flashes every 5 sec	12.26-12.5 volts	61 to 80% state of charge
	**GREEN** LED **5** flashes every 5 sec	12.51-12.7 volts	81 to 99% state of charge
	**GREEN** LED **6** flashes every 5 sec	12.71-13 volts	100% state of charge
	**GREEN** LED **2** flashes per sec	13.01-13.5 volts	
	**GREEN** LED **5** flashes per sec	13.51-14.0 volts	
	**GREEN** LED Steady/Constantly on	14.01 volts or higher	
	**ORANGE** Constant or Flashing - At or Near Dump Voltage		
	**YELLOW** Flashing - Relay Active (This LED is located just above the relay terminal)		
	**RED** and **GREEN** LED Alternating – Equalization Mode. Ends if it Accumulates 2 hours time with battery at 15.4 to 15.5 volts, until 48 hr timer runs out or the test button is pushed canceling Equalization Mode.		
	**RED LED Constantly on and Alarm sounding – Over Voltage condition .**		

If more precise Voltage monitoring is necessary, hook an accurate voltmeter directly to the batteries.

TROUBLESHOOTING

Symptom	Probable Cause	Solution
Status LED Flashes Random Combinations	Bad or corroded wiring connection.	Check, clean and/or tighten all connections.
RED LED 1 flash every 20 sec and alarm chirps	Dead battery Bad or corroded wiring connection.	Charge battery. Check, clean and/or tighten all connections.
RED LED Constantly on and Alarm sounding – Battery Over Voltage condition (Discontinued on boards marked SV3.1 and up)	Relay malfunction, Bad or corroded wiring connection. Dump load too small.	Check for bad relay. Check, clean and/or tighten all connections. Increase load.

SPECIFICATIONS

Min. Operating Volts	5 VDC	**Max. Operating Volts**	35 VDC
Nominal Operation Voltage	12VDC	**Temperature Compensation (Optional) (BV4.2.8-R)**	-5°F(-20°C)-130°F(55°C) .028V per cell per 1°F -40°F(-40°C)140°F(60°C)
Dump/Absorption Adjustment Range	13.1 to 15.1 Volts ± 1% 0.155V	**Equalization Voltage Adjustment Range**	14.5 to 16.5 Volts ± 1% 0.155V
Battery Voltage Regulation (High/Low Volts Using EMRs)	± 6% 0.93V **Average Stabilized (This can fluctuate due to system variables!)**	**Battery Voltage Regulation (High/Low Volts Using SSRs)**	± .4% 0.062V **Average (This can fluctuate due to system variables!)**
Status LED Accuracy	± .4% 0.062V	**Over Voltage Alarm**(Discontinued	Dump Voltage + 0.5V on boards SV3.1 and up)
Monitoring Power LED On	≤ 6ma	**Monitoring Power LED Off**	≤ 5.5ma
Power Max.	≤ 40ma	**Max. Power Sunk**	-800ma
Automotive style ElectroMechanical Relays	1 to 6 30 to 40 Amp with 12VDC coil	**Solid State Relays**	1 to 32? DC-DC
Operating Temp.	-20°C to 50°C	**Storage Temp.**	-50°C to 150°C
Dimensions	75 mm x 105 mm	**(2.95 in. x 4.13 in.)**	

Specifications subject to change without notice.

Made in USA

Components-Rest of World

WARRANTY:

WindAndSunPower.com. Model 1URDC is warranted to be free of defects in material and workmanship for three years from the date of purchase. Failure to provide correct installation, operation or care for this product, in accordance with the instruction manual, will void the warranty. Product liability shall be limited to repair or replacement, at the discretion of the manufacturer. 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, abusive conditions, lightning, or exposure to weather. No specific claim of merchantability shall be assumed or implied beyond what is printed in this manual. No liability shall exist from circumstances arising from the inability to use this product, or it's inappropriateness for any specific purpose. 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.

RETURN PROCEDURE:

To return a model 1URDC for warranty service please contact WindAndSunPower.com for return authorization and shipping instructions. Provide the following information shipped with the controller. Name/Company name, return address, daytime phone number, description of failure, copy of sales receipt. Include $4.00 for return shipping