Do-It-Yourself Heated Clothing

Background:
Searching the World Wide Web resulted in a few “how to” descriptions, but they mostly lacked detailed instructions that would take a lot of the guesswork out of it. The ideas are not original; I only sought to document the effort in sufficient detail that others may be able to adapt it to their needs. My goal was to integrate some riding clothes I already had with some do-it-yourself materials to create a plug-and-play heated clothing system for use with my motorcycle (2006 Royal Star Venture).

Clothes I already had: 1A. Fieldsheer High Temp Mesh Armor Jacket w/ zip-out liner; 1B. US Army Improved Physical Fitness Uniform (IPFU) black insulated (warm up) pants.

New Cost $0


1A.


1B.

Commercial products I chose to buy: 2A. Warmgear 12v Classic Leather Gloves ($130) [or Gerbing Classic Heated Gloves ($139)]; 2B. WarmGear Heat-Troller Single Portable Temp-Controller WG-SPCOAX ($70); 2C. WarmGear SAE to Coax Jack (Female) WG-DCJK150SAE ($5); 2D. WarmGear Belt Pouch for Single Portable Heat-Troller Temp-Controller ($10)

New Cost $215


2A.


2B.


2C.


2D.

Components needed to make electrical distribution system and heated jacket liner (and pants at a later date): 3A. 25 feet 18 AWG Zip Cord ($10); 3B. 100 feet of 30 AWG multistranded Teflon coated wire ($21); 3C. Wire splice connectors and crimp type barrel connectors ($5); 3D. Size L 2.5mm Coaxial DC Power Plug ($6); 3E. Lamp cord in-line switch ($3)

New Cost: $45


3A.


3B.


3C.


3D.


3E.

Total New Cost: $260

Operating Hook-up configuration:
My motorcycle already had a factory SAE jack attached to the battery (typically for a battery tender). Plug SAE-to-coax adapter (2C) to the battery SAE jack, then plug the red heat-troller coax (2B) (battery side) to the coax/SAE adapter (2C) (in lieu of using the battery harness that comes with the heat-troller), and plug the black heat-troller coax (2B) (regulated side) into the jacket coax (3D) so the voltage flows from the battery through the "thermostat" to the gloves and the jacket liner heating elements.

Electrical Analysis:
Refresh your memory on some basic electrical laws:
Voltage = Resistance X Current = (Ohms Ω X Amps)
Watts = Voltage X Current = (Volts X Amps)

Researching the Royal Star Venture electrical system resulted in the following approximations:

Charging system total = 406 Watts (14 Volts x 29 Amps @ 5000 RPM).
Once the battery charging requirement is set aside, it is estimated that 250-350 Watts are available to the motorcycle for use (some systems always in use, some periodically used).

Major "constant" power drains (Total = 280 Watts)

- Carburetor heaters = 60 Watts (4 x 15 W)
- Headlight = 60 Watts
- Tail light = 27 Watts
- Signals (Front & Rear) = 54 Watts (27 ea Front & Rear)
- Turn signal indicator = 7 Watts
- Radio (using headset) = 2 Watts
- Accessory Passing lamps = 70 Watts

Estimated best case scenario: 350 Watts – 280 Watts = 70 Watts (available). Estimated worst case scenario: 250-280 = -30 Watts (battery discharging). Selecting to turn off the passing lamps frees up 70 Watts that can provide some latitude in using at least some portion of the heated clothing system. Accuracy of these estimates is subject to debate and interpretation. Determining "true" available wattage is beyond my expertise.

Assume the battery produces 12 Volts. The laws of electricity calculate (best case) 70 Watts ÷ 12 Volts = 5.8 Amps to work with. However, the motorcycle has a factory 7.5 Amp fused SAE accessory plug attached to the battery, so we will assume that we actually have 7.5 Amps to work with (x 12 Volts = 90 Watts) before the fuse blows or the battery reaches a discharge condition. A voltmeter can give some indication whether the heated clothing is eating into the battery's capacity. If you draw more current from your system than the alternator can provide, the rest must come from somewhere and that 'somewhere' is your battery. You don't want to end up with a dead battery.

Typical commercial heated clothing
Warmgear heated gloves = 2.3 Amp draw (28 Watts)
Warmgear heated jacket = 3.7 Amp draw (44 Watts)
Warmgear heated pants = 2.6 Amp draw (31 Watts)
Total = 8.6 Amps (103 Watts) if all used simultaneously

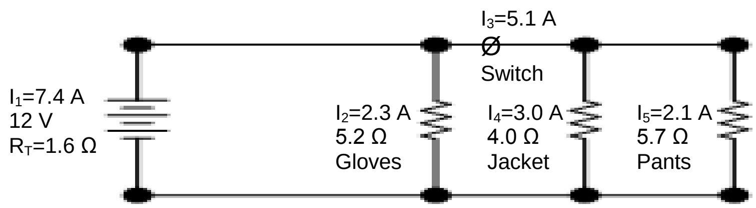
My goal is to balance the design Wattage of the do-it-yourself portion with the given Wattage of the commercial gloves to keep all the heated items within the 7.5 Amp limit of the existing accessory plug (12 Volts x 7.5 Amps = 90 Watts).

Circuit Design:
Additional electrical laws:
Total current that flows into a junction must also flow out of it ($I_1=I_2 + I_3, I_3=I_4 + I_5$)
Combined Resistance in a parallel circuit is less than each individually ($1/R_T = 1/R_1 + 1/R_2$)

Basic premise for this design is heat will always be available for the gloves since my hands tend to need heat before my body. The power distribution wires snaked into the jacket will include an on/off switch downstream of the gloves branch. This way the gloves will always have power and the switch will turn on/off the current flow to the jacket liner heating element (and to the pants plug to be added later), thus creating a minimum and maximum drain on the battery charging system.

Power source:
Battery provides 12 V DC
Accessory fuse is rated to 7.5 Amps (use 7.4 Amp max to keep the fuse from blowing)

Circuit branch requirements:
Warmgear heated gloves = 2.3 Amp draw (28 Watts)
Available for Jacket and Pants = (7.4-2.3) = 5.1 A



Balanced Solution:
Since available Wattage (5.1 A x 12 V = 61 W) is less than Wattage rating of commercial clothing (44 W + 31 W = 75 W), my design limits the jacket and pants to 80% (61 W ÷ 75 W) of the typical commercial jacket and pants (Amps and Watts). Additionally I would keep jacket and pants proportional to each other (pants are 70% of jacket Amps and Watts).

Wire characteristics:
The 18 gauge lamp (zip) wire has very little resistance, and we will assume it is negligible in the power distribution wiring.
The 30 gauge wire measures 0.1 Ohm per foot of wire.
By balancing the wattage between jacket and pants (70% of jacket) within the allowable current (61 W = Jacket + .7xJacket; therefore Jacket = 36 W and the pants = 25 Watts), this design allows (36 W ÷ 12V = 3.0 A) 4 Ohms for the jacket and (25 W ÷ 12V = 2.1 A) 5.7 Ohms for the pants. This translates to 40 feet of wire for the jacket (40 feet x .1 Ohm/foot = 4 Ohms) and 57 feet of wire for the pants (57 feet x .1 Ohm/foot = 5.7 Ohms).

Notes on Components:

- 30 gauge, multi-strand, Teflon coated copper wire - this usually comes in 100' spools. Order from bulkwire.com.
- 18 gauge, insulated wire - lamp cord or similar. This wire runs from the garment to the receptacle socket so the length will vary depending on the installation. 25' should be sufficient. Black/Red wires make it easy to keep track of positive/negative wires for connections. Order from bulkwire.com.
- In-line lamp switch - putting one on the clothing to turn it on/off downstream of the always-on glove circuit will help control the power distribution to the clothing and prevent having to plug/unplug more than a single external connection (except for the pants, which

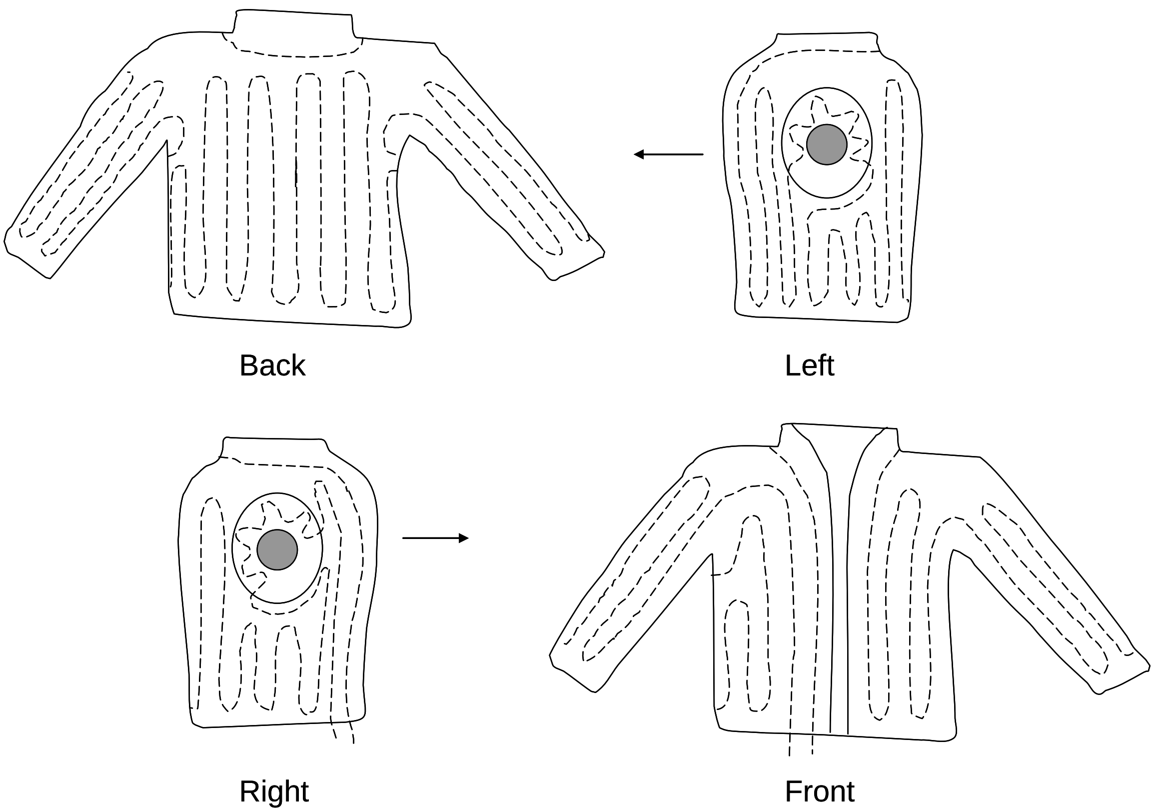
are the last layer to heat). Additionally use Warmgear Heat-troller to vary the voltage/wattage (temperature) going to the system.

- Crimp type barrel connectors - to connect the 30 gauge heating wire to the 18 gauge cord
- Wire splice connectors – to connect the 18 gauge cord to other 18 gauge cord for the power distribution wiring.
- Coax plug/socket - to securely connect the wire harness from the clothing to the electrical source, but to allow for quick disconnect should you exit and forget to unplug. Compatible with Warmgear or Gerbing commercial products.

Construction:

<u>Jacket Liner heating element</u>

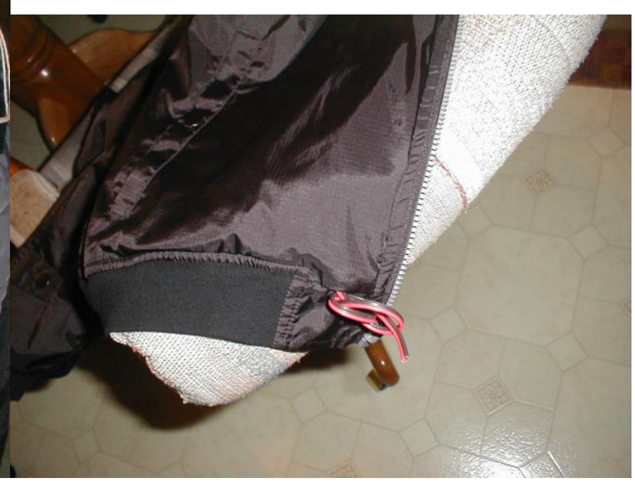
The object is to lay the wire so that there's equal heat distribution and no crossing of wires. Choose your entry point to coincide with the location where the splice will be made to the 18 AWG wire (probably near the waist on the front/right side).



(Liner inside out - keep in mind, left and right will be reversed).
I planned to lay out the 40 feet of wire by first laying out a string line guide. I cut 40 feet of string and marked it every 10 feet with a black marker. I used safety pins to anchor the string at each back and forth change of direction. I divided the jacket area into four quadrants and made adjustments to the string spacing to make sure each 10 foot section covered one fourth of the jacket.


Photographs: left and right – String line guide layout on back and front of liner (inside out)

Measure and cut 41 feet of the 30 gauge wire and thread one end on a 4” long large-eye needle. Starting at the front waist of the jacket liner near the zipper, insert the needle at a low angle so the wire runs shallow, just under the fabric surface and not through the insulation, bring the needle back out about 4" down the string line guide then dive right back under for another 4" and repeat while following the string line guide. Work from the front right zipper to the right side and right sleeve, around the back, the left sleeve and left side, then the left front, around the back of the neck, and the right front, returning to the zipper area where you began. Leave six inches (6”) of 30 gauge wire at the entry point, but pull all the wire through each time you make a turn in direction. Be patient and take your time. Doing this part correctly the first time will save a lot of time and energy.

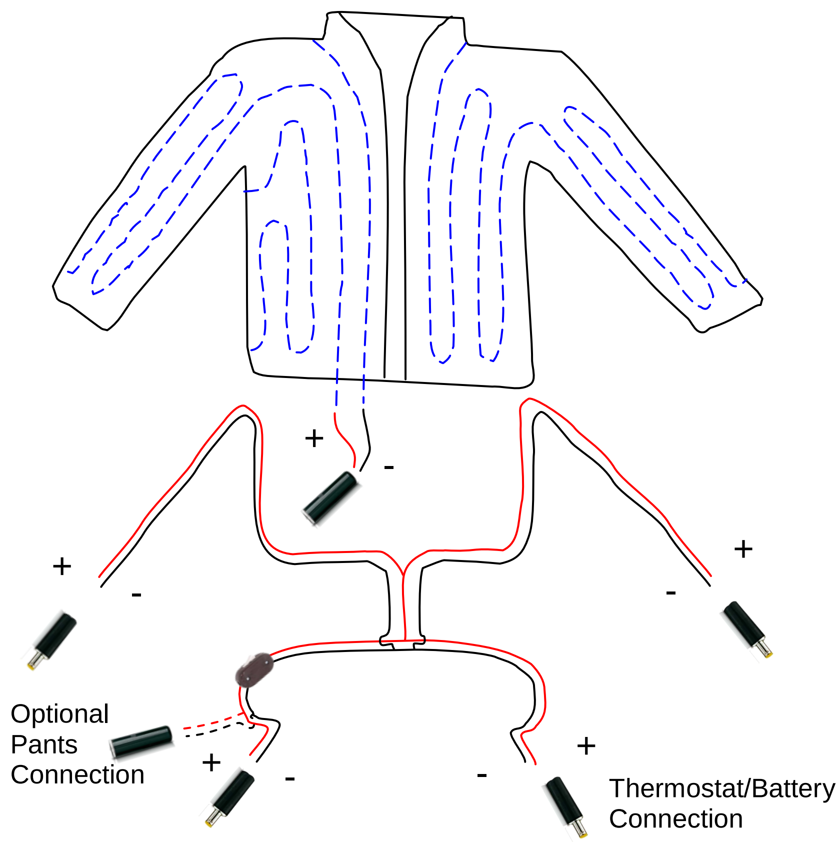



Photograph: left – 30 AWG on needle following string line guide
Photograph: right – 18 AWG pigtail connected to both ends of 30 AWG (starting point/ending point)

After the 30 gauge wire enters the jacket liner (leaving 6" tail), circulates all around the jacket evenly with no crossed wires, and emerges at the same entry point (also leaving 6" tail) the weaving of the heating element is complete. The entry/exit location is where the coax coupler will be wired in. Cut a short length of 18 gauge wire stripping the insulation off one end. Use crimp connectors to attach one 30 AWG to black 18 AWG and one 30 AWG to red 18 AWG. A grommet or knot to keep the connection point inside the liner will help to keep any strain from pulling on the 30 AWG.

<u>Mesh Jacket power distribution wiring</u>

Since this design features quick connections for gloves-to-jacket and jacket-to-liner (and future capability for jacket-to-pants), a power distribution network needs to be run. The mesh material and heavy denier nylon of my jacket did not require grommets or reinforced buttonholes, but they may be useful to create neat, reinforced entry/exit points (and strain relief). The 18 gauge lamp wire will start at a coax plug on the outside left side of the mesh jacket and follow the waist of the jacket around to the right side and end with a coax on the inside of the mesh jacket for the zip-out liner to connect to. At the center of the back waist band will be a Y-branch which will travel up the back to the sleeves and down to the cuff. Between the Y-branch for the gloves and the coax connection point for the jacket liner heating element is where you also may wish to add an on/off switch. This way the gloves will always have power once you connect the primary male coax to the battery female coax. The jacket liner heating element would only have power if you turn on the switch (which would also supply power to the pants if they were plugged in with the optional second coax jack).



Photograph: left top – 18 AWG waistband distribution wire with switch
Photograph: right top – 18 AWG Y-branch connection lower center back
Photograph: left bottom – 18 AWG glove connection sleeve coax plug
Photograph: right bottom – 18 AWG coax plug detail

<u>Final Assembly</u>

Soldering the 18 gauge wire to the power connectors was a bit of a challenge. I had to enlarge the pin holes in the positive and negative terminal arms to feed the wire through and bend it back on itself. If the terminal connections are too bulky, the plastic cover tube will not slide over the "solder bubble" and won't screw into the connector. Also it is wise to connect the exposed power connector to the battery connector and determine positive and negative terminals using a multimeter. This will ensure you don't invert the voltage – then you need to be consistent in attaching red wire to positive and black wire to negative throughout the jacket. With all the wire run and wire to wire connections crimped and coax connections soldered, the finishing touches included lashing the 18 AWG wire to the mesh of the jacket with thread to keep the wires from shifting around. Elastic ribbon fabric was used to create snug tubes sewn to the sleeves to keep the glove coax jacks in place. Pile (Velcro) fabric was stitched to the inside waist of the mesh jacket and the opposite Hook fabric was glued to the lamp switch to keep the switch in place just underneath the waist edge of the mesh jacket.

Operational Test and Use:
I have used the heated gloves and jacket for two winters and I am happy with the result. In hot weather the liner zips out and the power distribution wires within the mesh armor jacket are hardly noticeable. In hindsight I would probably recalculate the Amps and eliminate the heated pants

and allow more Wattage for the jacket. I have not wired the pants for heat and I'm not convinced I really need to.

The temperature controller pouch clips onto a waist adjustment strap on the jacket within easy reach while riding and close enough to connect to the battery power connection pigtail. The gloves can be easily connected with one hand because the power connector on the jacket sleeve is held in place with elastic. The jacket switch is easy to find at my right hip at the bottom edge of the jacket and even with bulky gloves it is easy to feel and operate. I tend to turn the thermostat off, then switch the jacket on or off (gloves are always powered), then turn the thermostat back on so as not to cause a surge or drop on the thermostat. When both gloves and jacket are on full thermostat (temperature in 20's and low 30's), I've observed my voltmeter drop one light (I.e. from normal 2 red/ 2 yellow/ 1 green to 2 red/ 2 yellow). I may be operating at the limit of the charging system, but the original 2006 battery seems to be going strong.

WORKS GREAT!

Photograph: above left – Nearly complete, power distribution wires under the mesh are temporarily lashed to jacket mesh with string (look closely on sleeve and down the back).
Photograph: above right – Jacket liner unzipped to reveal connection of mesh jacket power distribution to jacket liner heating wire.
Photographs: below – Complete, front view one glove connected at sleeve, grey temperature controller connected to jacket, red battery connector dangling.