Hi-Z TECHNOLOGY, INC.
Thermoelectric
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To ensure maximum performance of your thermoelectric module, please note the following “Design Guide”. This guide is specific for the HZ-14HV module and is only intended as a guide for testing the module.

For differences between this module and other Hi-Z modules please refer to the note at the end of this document.

Required materials:

- HZ-14HV Module (1)
- Heat sink (1)
- Heat source (1)
- Fan for heat sink (1)
- Thermal grease (20 grams)
- Alumina wafer (2)
- Two different colors of 18 gauge wire
- Wire cutters
- Wire strippers
- Soldering iron
- Tin or lead-tin solder
- Flux (optional)
- Belleville springs
- Milliohm resistance meter (AC or pulsed DC)
- multimeter
- Load resistor
- Thermocouples
- Thermocouple reader
- Switch

Testing Hi-Z Thermoelectric Modules: Design Guide

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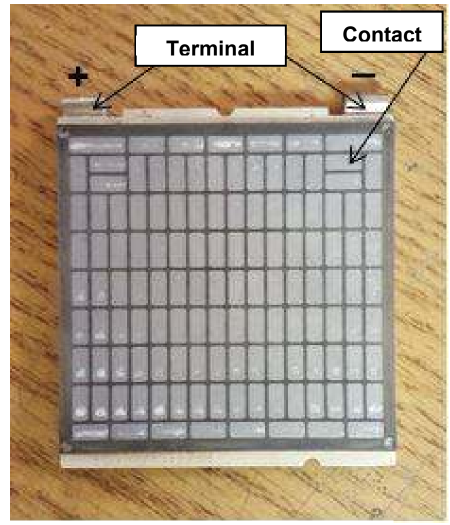

Figure 1: HZ-14 High Voltage

1. **HOT AND COLD SIDE IDENTIFICATION: Figure 1** exhibits the HZ-14HV module cold-side up. There are two terminals on the top of the module, as shown in the figure. The terminal on the left is positive (+) and the terminal the right is the negative (-). These are labeled in Figure 1.

2. **ADD WIRE TO LEADS:** Cut two pieces of 18 gauge wire about two feet in length.

3. **STRIP AND TIN** Strip about 3/8" of the jacket off of each end of the wires. Tin the exposed wire ends. Tin solder works well for this application.

4. Solder the lead wires inside the terminals as shown in **Figure 2**. Make sure that they are attached securely. Do not use alligator clips. Wires attached with solder have the lowest resistance and will provide the best results.

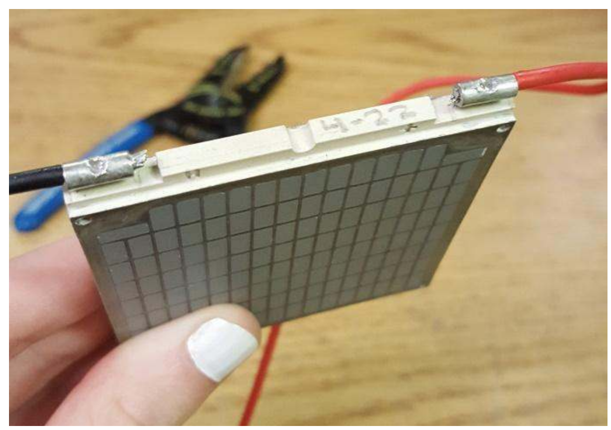

Figure 2: Module with soldered lead wires

5. You will need both a cold surface and a hot surface (a heat sink and a heat source, respectively). Examples of each are pictured in **Figure 3**. The heat source is made of steel and can be heated by either a flame or a hot plate (not shown). The heat sink is made of aluminum and is cooled by a fan (shown in the figure). Heat sinks can also be cooled by water flowing through holes drilled into a solid material.

6. The heat sink and heat source should have a thermocouple wells (shown in **Figure 6**) drilled into them. This is needed to accurately measure the temperatures as they change.

7. The sides of these surfaces that make contact with the module must have a flatness of ±0.001" or better. ±).0005" is ideal. The surfaces must also have a smoothness of at least 32 RS. There are microscopic irregularities in any surface even if it appears flat. The fewer the irregularities, the better the heat transfer.

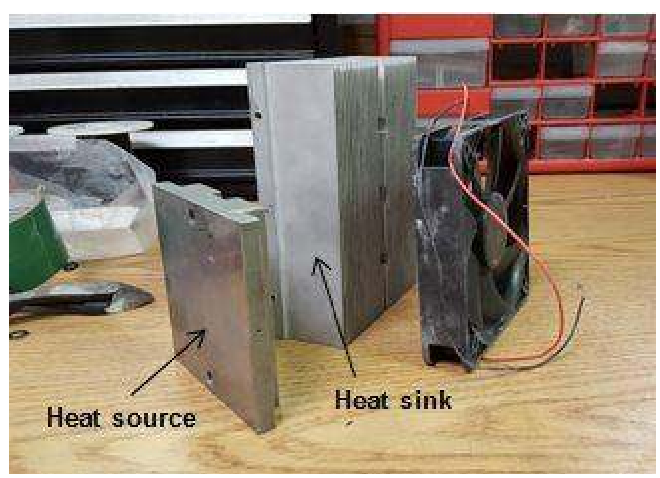

Figure 3: Heat source and sink

8. Using an acid brush and/or your finger (see **Figure 4)**, apply a thin, even layer of thermal grease to the heating and cooling surfaces that will make contact with the module (smooth sides). Thermal grease helps with heat transfer.

9. Using an acid brush and/or your finger, apply a thin, even layer of thermal grease to both faces of the module.

10. You will need insulators on either side of the module because electrical current flows through the module contacts (labelled in **Figure 1**). Alumina (Al_2O_3) wafers, as shown in **Figure 5**, are ideal for this purpose.

11. Assemble with the module with insulators in between the hot surface and the cold surface with the insulators on either side of the module as shown in **Figure 6**. Take extra care to make sure that the hot side of the module is facing the heat source and the cold side of the module is facing the heat sink. The module shown in **Figure 5** is facing hot side down because that is the side that will face the heat source.

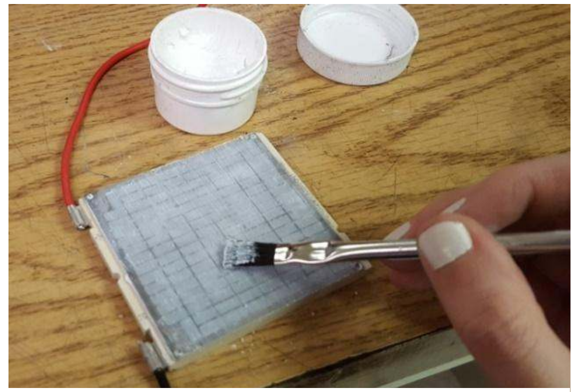

Figure 4: Spreading Thermal Grease

12. You will need to apply at least 100 psi of pressure to the module but don't exceed 200 psi. The module performs best under compression. Compression also maximizes the heat transfer between the surfaces. The best way to add compressive force to the module is using Belleville springs. Belleville springs apply a great deal of force in a compact space and allow for thermal expansion. If the assembly is simply bolted together, thermal expansion will quickly reduce the pressure.

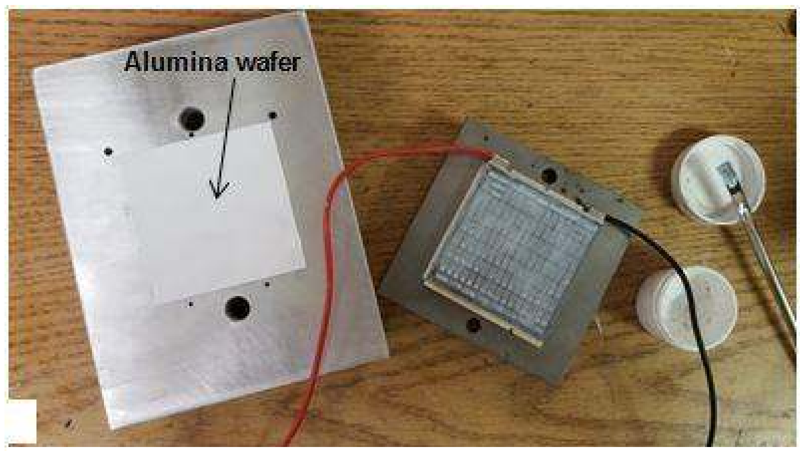

Figure 5: Module insulation

13. Careful attention must be paid to the clamping system to ensure that the load is evenly distributed. If there is too much force on a small area bowing will occur, which will prevent proper heat transfer and may damage the module. Combining the Belleville springs with a clamp that applies pressure to the center of the module, as shown in **Figure 7**, is a good way to prevent bowing.

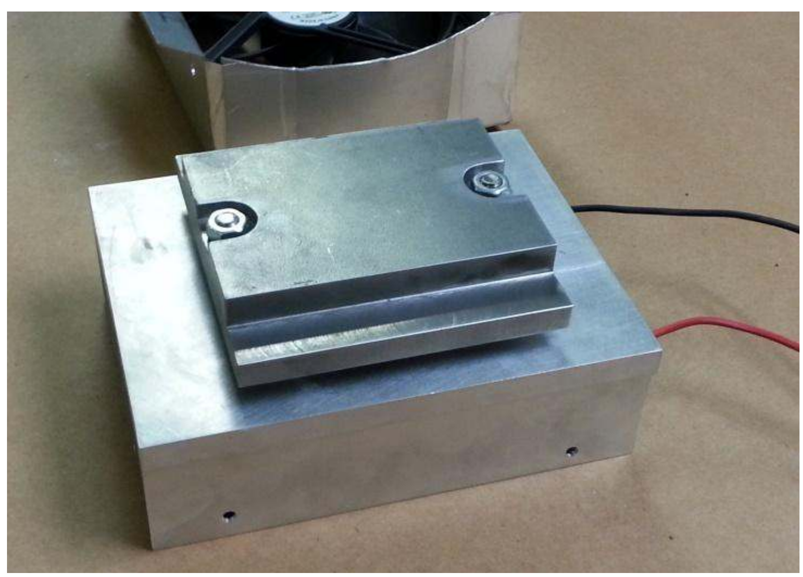

Figure 6: Assembled Test Fixture

14. Connect an AC resistance meter between the lead wires. If you are using a 4 wire meter, be sure to connect the two voltage probes inside of the two current probes. Take a module resistance reading at room temperature. The resistance of the HZ-14HV should be somewhere between 100 and 200 mΩ. Refer to the note at the end of this document for expected resistance readings for other H-Z modules.

15. Measure the resistance between one of the module lead wires and the hot and cold plates, respectively. An example of this is shown in **Figure 8**. Repeat this process using the other lead wire. The resistance should be open circuit or a very high value. If you are not getting very high values, one or more of your surfaces is shorted to the heat exchangers indicating that it has been assembled incorrectly. Double check your work.

16. Connect a load resistor between the two lead wires of the module. Arrange the circuit so that you can create an open circuit by flipping a switch or disconnecting one of the wires to momentarily break the circuit.

17. Connect a multimeter between the switch and the module on one side and between the resistor and the module on the other side. The voltmeter will read the voltage drop across the module (V_L) when the switch is closed and when the switch is open (Vo).

18. Calculate the current flow by connecting the multimeter across the load resistor (Rl) and measure the voltage drop across the resistor (Vr) when the current is flowing.

$$I = \frac{Vr}{Rl}$$

19. Calculate the internal resistance (Ri) of the module.

$$R_i = \frac{(V_O \ * V_l)}{I}$$

20. Record the hot and cold temperatures as well as the open- and closed-circuit voltages at several intervals between room temperature and 250°C. Record the open circuit voltage about a second after the switch is opened. Use these values to calculate the power, P_{MAX}, with the following formula:

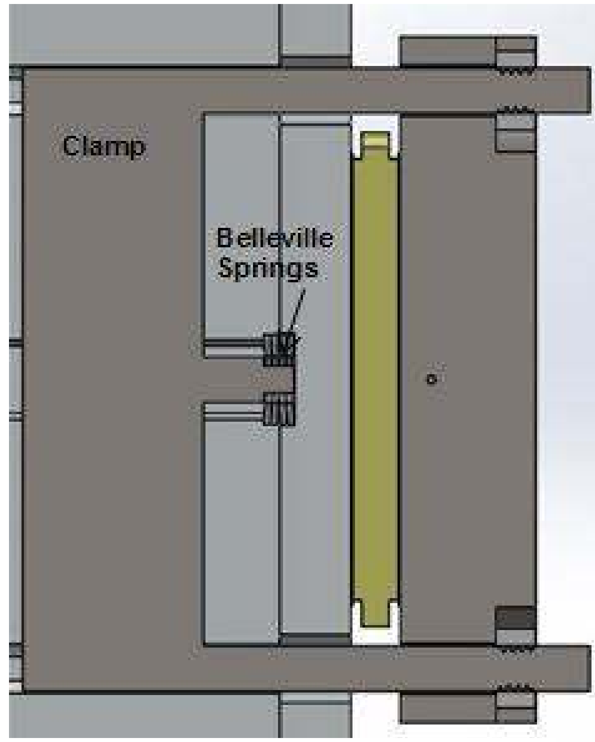

Figure 7: Compression assembly

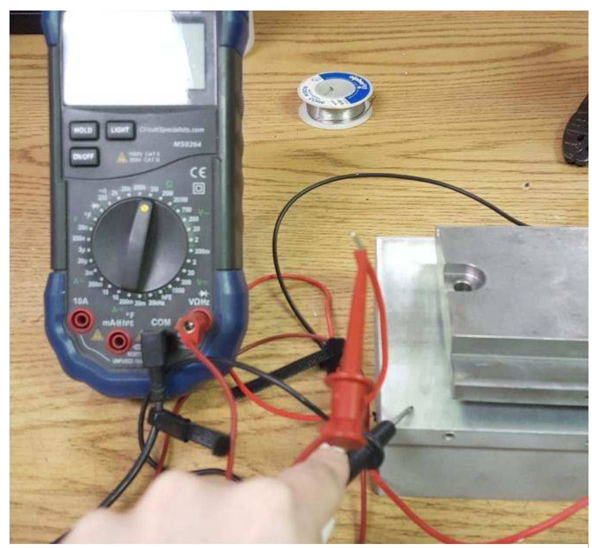

Figure 8: Testing for short circuits to ground

$$P_{MAX} = \frac{(V_O^2)}{4 * Ri}$$

Where, V_O= the open circuit voltage
V_L= the load voltage
Vr= voltage across the load resistor
R_i= the internal resistance

Time	Hot side temperature	Cold side temperature	Open circuit voltage	Loaded voltage	Current	Internal Resistance	Power

Note: HZ-20: the hot side is identified by the presence of round circles at the intersections of the contacts.
With the cold side up and the terminals towards you the negative lead is on the left
A suitable load is about 0.25Ω to 0.5Ω.

HZ-2: the hot side is identified by a letter "H"
The polarity is identified by a "+" and "-"
A suitable load is 4Ω to 5Ω.

HZ-9: the hot side is identified by the presence of round circles at the intersections of the contacts.
With the cold side up and the terminals towards you the negative lead is on the left
A suitable load is about 1Ω to 1.5Ω.