AIoT Consulting

The Adjustable Thermostatic Relay

Guide to building a portable version of the project.

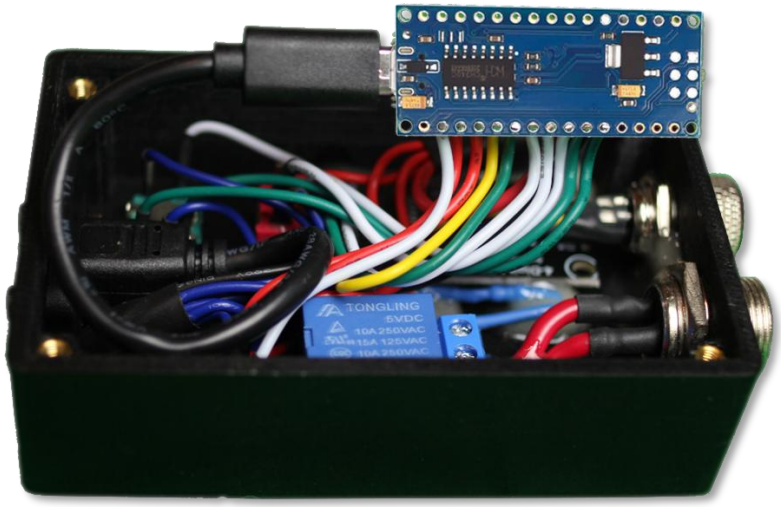


Table of Contents

1. **Background** 3
2. **Parts Required** 4
3. **Project Case Choice** 5
4. **Affixing the Cover Label** 7
5. **Pre-wiring the components** 8
6. **Installing components in Project Case** 11
7. **Wiring our Positive and Negative wires** 14
8. **Wiring the microcontroller** 16
9. **Installing female connector to Temperature Sensor** 17
10. **Final assembly & testing** 19

Appendix A .....

ATR Component Wiring Diagram 21

Appendix B .....

ATR Software & Online Course Information 22

Note: *Software for this project can be obtained from the reference in Appendix B*

1. Background

This guide has been created in conjunction with the online project course "**Arduino Nano Thermostatic Relay Electronics Learning Project**" to help you build a more permanent and portable version of the Programmable Thermostatic Relay.

This guide will help you build a professional looking Automated Thermostatic Relay unit enclosed in a project box using downloadable 3D printer files or use drill hole templates and labels on a commercially available project case. The guide includes a list of all the required parts as well as step-by-step instructions and illustrations for installing and wiring all the components.

The fact that there are so many real-world applications for this type of device is compelling enough for us to have created this guide. Whether you're looking for a way to keep the liquid temperature of some container between certain values or want to cool something which is getting too hot, this practical project will help you achieve this.

2. Parts Required

The following is a comprehensive list of all the parts required to complete and build a functional and portable version of the Arduino Nano Thermostatic Relay Learning Project in its very own project case.

We've also included a link to a source as an example for each item in the list for your reference. Keep in mind that these are not an endorsement or a recommendation of the source nor can we be responsible for problems in their supply chain or fulfilment. These examples are from online stores in North America, so please make sure to first check and see if these parts or equivalents can be sources locally.

Parts	Qty	Example sources
Arduino Nano Board	1	Arduino Nano | Arduino Official Store
DS18B20 Waterproof Temperature Sensor	1	HiLetgo DS18B20 | Amazon.com
4-Digit LED TM1637 Display Module	1	HiLetgo 4-Digit LED | Amazon.com
Panel Mount Rotary Encoder	1	Rotary Encoder (Panel Mount) | Amazon.com
SPST Mini ON/Off Toggle Switch	1	SPST Mini ON/Off Toggle Switch | Amazon.com
5V One Channel Relay Module	1	HiLetgo 5V One Channel Relay | Amazon.com
Red & Green LED's Pack (Small 3mm LED's)	1	Pack of assorted 3mm LED's | Amazon.com
Assorted Resistors Kit	1	Assorted Resistors | Amazon.com
GX12 Male Female 12 mm 3 Pin Connectors	1	GX12 Male Female 12mm 3 Pin Connectors | Amazon.com
GX16 Male Female 16mm 2 Pin Connectors	1	GX16 Male Female 16mm 2 Pin Connectors | Amazon.com
Stranded Wire Kit 22 Gauge 6 Colors	1	Wire Kit 22 Gauge 6 Colors | Amazon.com
Electrical Wire 14 AWG 14 Gauge Silicone Wire	1	Electrical Wire 14 AWG | Amazon.com
M3 Threaded Insert Knurled Brass Nuts Female (if using 3D printed case)	1	M3 Brass Inserts (Pack) | Amazon.com
M3 x 10mm Alloy Steel Hex Socket Head Cap Screws (if using 3D printed case)	1	M3 x 10mm Hex Cap Screws (Pack) | Amazon.com
M2 Threaded Insert Knurled Brass Nuts Female (if using 3D printed case)	1	M2 Brass Inserts (Pack) | Amazon.com
Panel Mount Extension Mini B USB Cable - for Nano models with Mini USB	1	Panel Mount Extension Mini USB Cable | Adafruit.com
5V 2A Mini USB Power Supply Wall Charger	1	Mini USB Power Supply | Amazon.com
Fielect Project Box (or use 3D print file to make your own)	1	Fielect Project Box 3.94" x 2.36" x 0.98" | Amazon.com

3. Project Case Choice

Before you start building, you'll need to decide whether you are going to use a manufactured project case such as the one listed in the parts list or use a 3D printer and print your own using the files included in the resources folder of the online course or from this link.

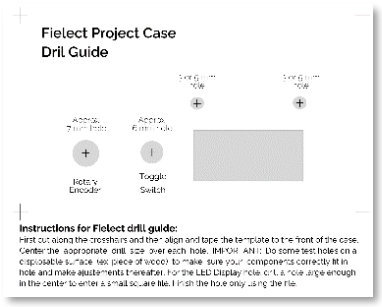
Using the 3D printed case will save you time as you will not need to drill or cut any holes. For the purposes of this guide, we'll use the 3D printed case for all our illustrations.

Above is a picture of the project case and cover. (dimensions: 4" L x 2.6" W x 1.25" H)

However, if you don't have access to a 3D printer, you can use the manufactured case listed in the parts list (or something similar) and use the printable templates we've included in the resources folder of the bonus lecture (or this link) to help you in cutting and drilling the holes for the various components. If you do decide to use these templates, keep in mind they were designed specifically for the case listed in the parts list (Fielect ABS Plastic Project Box 3.94" x 2.36" x 0.98") and when printing the template, make sure to print them at 100% size. Also, double check before making any cuts.

You'll find that drilling the round holes is the easy part, cutting the square hole for the 4-digit LED display is the hard part. Here, we strongly suggest you first cut/drill well within the lines of your square hole and then use a small flat file to finish. This will take some time, but you'll be happy with the results.

If you decide to make your own 3D print of the case, use both the file named ATR-USB-Case.stl and the file named ATR-USB-Cover.stl. Both files can be read using 3D printer software such as Cura by Ultimaker. You can download a free copy of Cura here. Simply take these files to a 3D printer service provider or print them yourself if you own a 3D printer.


Fielect Project Case
Dril Guide
Rotary Encoder
Toggle Switch
Instructions for Fielect drill guide:
First cut along the crosshairs and then align and tape the template to the front of the case. Center the appropriate drill size over each hole. IMPORTANT: Do some test holes on a disposable surface like piece of wood to make sure your components correctly fit in hole and make ajustements thereafter. For the LED Display hole drill a hole large enough in the center to enter a small square file. Finish the hole only using the file.

4. Affixing the Cover Label

Before you can begin mounting your components to the case, you will need to print and affix the cover label to your project case. We recommend you use high quality glossy sticker paper as it will make it much easier to affix to your project case. We've had very good results with this Glossy Silver paper. Use the appropriate file from the resources folder of the bonus lecture to print the cover label using 100% for size and the highest resolution available. Once printed, cut the label as per the instructions on the label and shown in figure 1a.

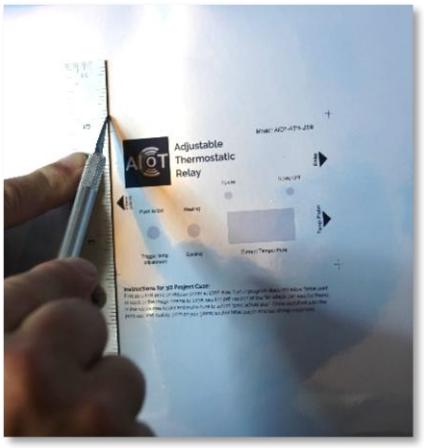


Figure 1a

Peel and carefully remove the protective layer from your sticker paper and carefully align the cover label on the project case. We recommend taking your time here and first aligning the left side and aligning your label before gradually setting it on the surface from left to right as per figure 1b.

Figure 1b

Once properly installed, use an X-ACTO knife to carefully cut the holes (figure 1c) for all the components. Again, take your time to achieve the best results.

After cutting all the holes for your components, we highly recommend that you spray a thin coat of clear lacquer directly on the label. This will help protect and preserve it.

Figure 1c

5. Pre-wiring the components

Prior to installing the components inside the project case, we will pre-wire them. This will make it much easier to manipulate the components as we solder the wires to them. We'll be using 22 AWG gauge for most of the components except for the GX-16 male relay connector where we will use 14 AWG gauge wires.

Let's start with the Rotary Encoder, initially cut each wire to four-inch lengths, they will be cut shorter as required in later steps. So cut (5) 4-inch 22 AWG gauge wires. If possible, use 2 blacks, 1 white, 1 green and 1 yellow as this will make it easier to connect later (figure 2a). Also, pre-solder the ends of each wire to make the next steps easier.

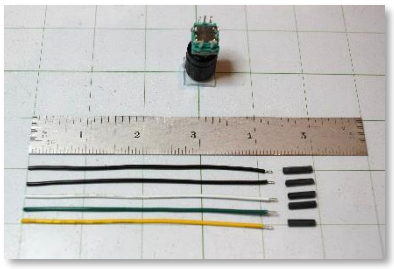


Figure 2a

After soldering your wires, we strongly suggest using some protective shrink tubing. As illustrated in figure 2b, to avoid any of the wires from shorting as they are in very close proximity of each other.

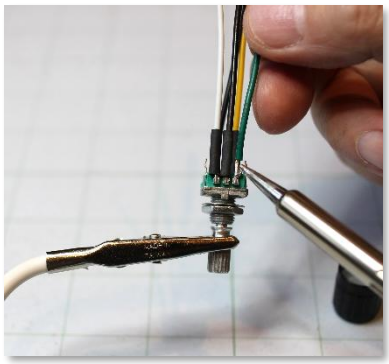


Figure 2b

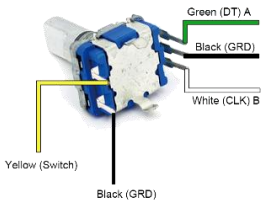


Figure 2c

Refer to figure 2c and solder the green wire to the DT (A) pin, two black wires to both grounds, the white wire to the CLK (B) pin, and finally the yellow wire to the switch pin.

Next, we'll pre-wire the TM1637 LED display. So cut (4) more 4-inch 22 AWG wires, 1 black for ground, 1 red for 5V, 1 white for CLK and 1 green for DIO. Here, make sure you solder the wires, so they are coming out of the back right side of the TM1637 as illustrated in figure 3. When we later install the LED display in the project case, the four wires will be located towards the middle of the case.

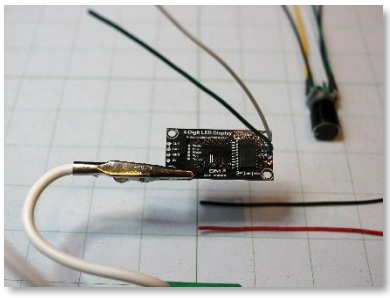


Figure 3

The next part we'll pre-wire is the Relay Module. Once again, cut (3) more 4-inch 22 AWG wires, 1 black, 1 red and 1 white. Here, make sure you solder the wires, so they are coming out of the top component side of the relay as illustrated in figure 4. This is important as the relay will be seated inside the flat portion of the case when we later install it. Make sure to also use protective shrink tubing if required.

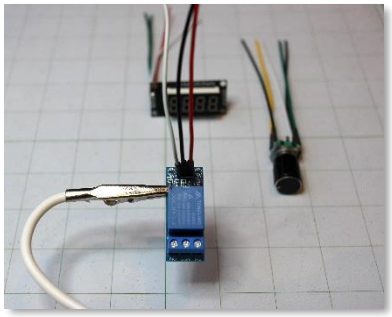


Figure 4

The next item we'll pre-wire is the mode selection toggle switch. Cut (2) 4-inch 22 AWG wires, 1 black and 1 yellow. If your toggle switch has three connectors, solder the black wire to the center connector and the yellow wire to either of the other two connectors. If your toggle switch has only two connectors, don't worry about which wire goes were. Make sure to also install some protective shrink tubing.

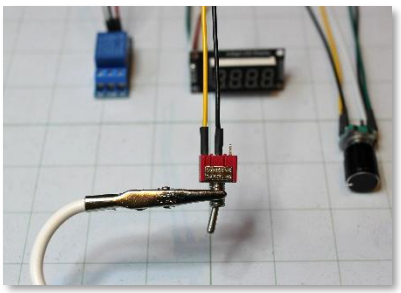


Figure 5

We'll now wire the two males ends of our GX12 and GX16 connectors. Cut (3) 4-inch 22 AWG wires, 1 red, 1 black and 1 yellow. Here we have soldered our red wire to pin 1, our black wire to pin 2 and finally our yellow wire to pin 3 (refer to figure 6a & 6b). Make sure to note the pins you use, as this will be important later when we wire our female connector to the temperature sensor. Also make sure to add some protective shrink tubing on each of the wires.

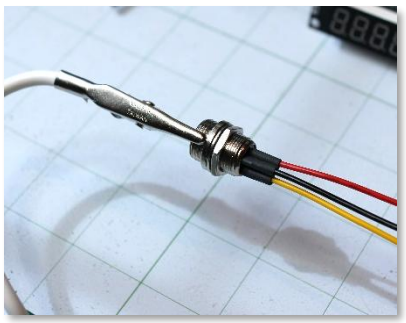


Figure 6a

Figure 6b

For the GX-16, we recommend that you use a larger gauge wire such as 14 AWG. So, cut (2) 2-inch 14 AWG wires. Depending on the connector you're using, you may need to remove a few strands at the end of your wires to obtain a better fit. When you're happy with the way the wires and connector terminals fit, pre-soldering both the connector and wire ends will make it easier to solder these larger wires. You'll also need to add some protective shrink tubing on these wires as well as shown in figure 7.

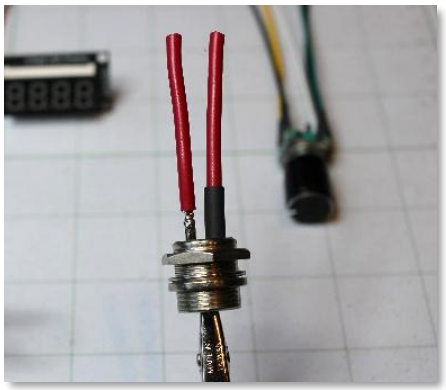


Figure 7

The last items we need to pre-wire are the two LED. First cut (4) 4-inch 22AWG wires, 2 reds and 2 blacks. You'll also need (2) 470 ohms resistors for this step. First cut both sides of your resistor to ¼ inch lengths. Also cut the leads of the positive anode sides of your LED' to ¼ inch. Solder one side of your resistors to the red wires, then solder the other side of your resistors to the anode positive side of your LED's. Next, cut the negative cathode side of your LED's leads to ¼ inch. Then solder the black wires to the LED negative cathodes. Finally, slip shrink tubing over both wires making sure to cover the entire resistor on the red wire as shown in figure 8. Once you have fully assembled your LED, we highly recommend you test them by applying 5 volts DC to confirm they are working correctly as we will be epoxying them onto the project case in a later step.

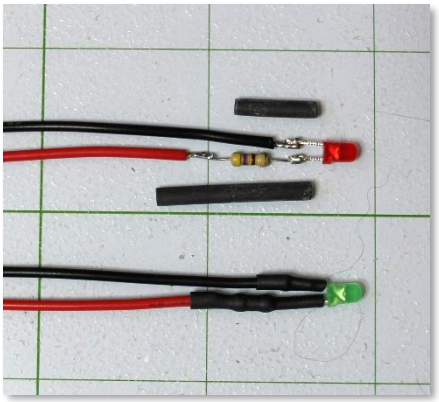


Figure 8

6. Installing components in Project Case

We'll now start installing the components inside the project case. You'll need some two-side mounting sticky tape to hold some of the components in place. You'll also need some 5-minutes epoxy to ensure that some of the components, such as the LED's remain fixed in place.

To install the TM1637 LED display, first loosely insert the 4 smaller M2 threaded inserts into the four posts holding the display inside the case (pay attention to the orientation as shown in figure 9). With the tip of your hot soldering iron perpendicularly position in the hole of the nut, apply slight downwards pressure until each of the nuts are flush inside the holes as illustrated in figure 9 & 10. The rectangular hole for the display may need to be slightly filed, so check the fit and if needed, lightly file the opening. Once satisfied with the fit, insert the display inside the project case with the wires toward the middle of the case as illustrated in figure 11, and secure with (4) M2 x 4mm Phillips screws.

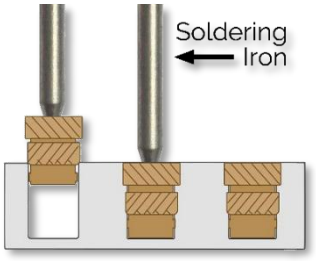


Figure 9

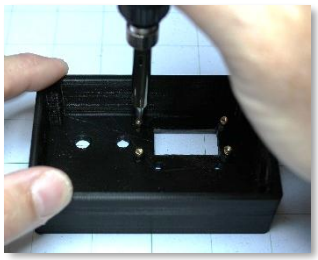


Figure 10

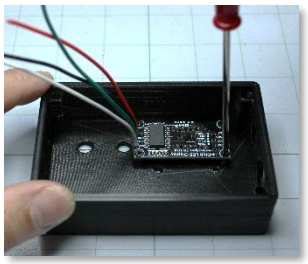


Figure 11

The next two components we'll install are the toggle switch and the rotary encoder. So, remove the securing nut from the shaft and install them onto the project case. Secure them with the nut and make sure to use the round washer when tightening and be careful not to scratch the surface of your label when tightening.

Next install the GX12 male temperature connector and secure it by first passing the washer and then the nut over the three wires. When tightening the nut, make sur that the alignment notch inside the connector is facing toward the front side of your project case as per figure 12.

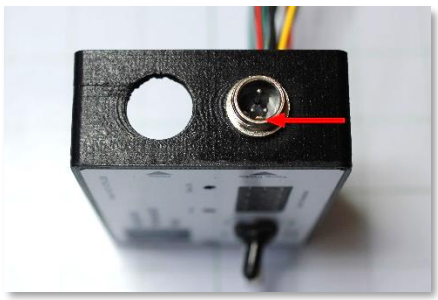


Figure 12

We will now position the GX16 male connector inside the project case, temporarily securing it with the washer and nut. Here again, make sur that the alignment notch inside the connector is facing toward the front side of your project case. Now enter the Relay Module into the project case holding it in place approximately ½ an inch from the left side (when looking toward the inside) of the project case. Using either your fingers or long nose pliers, bend the two 14 AWG wires so that they are aligned with both the normally open and common relay connectors as shown in figure 13.

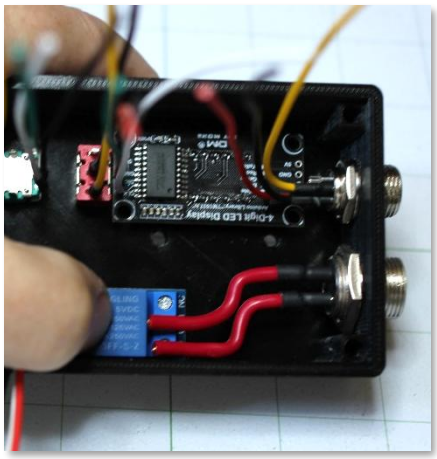


Figure 9

Once correctly aligned, remove both the GX16 and relay module from the project case. Carefully remove about ¼ inch of insulation on each of the 14 AWG wires. Now untighten the screws on the relay module and test fit the wire to see if you can easily insert them inside the relay's connectors. Depending on the model of your relay module, you may need to insert a very small flat screwdriver and delicately pry open the openings of the connector holes to allow for a bigger wire. Also, if needed, you may also remove a few wire strands from each wire until you get a nice fit inside both connectors. Next, cut a small square of two side mounting sticky tape equal or smaller than the bottom surface of the relay module. Peel-off and install the mounting tape on the bottom side of the relay module, but do not remove the protective film on the exposed side of the tape yet. Re-install the GX16 male connector to the project case and slip the both the washer and the nut over the two wires. Now position the relay module inside the case and first insert and tighten both wires to the Normal Open and Common connectors of the relay module. Next, tighten the GX16 nut and once everything is secure, peel the protective film from the back of the relay module and carefully position it in the project case as shown in figure 14.

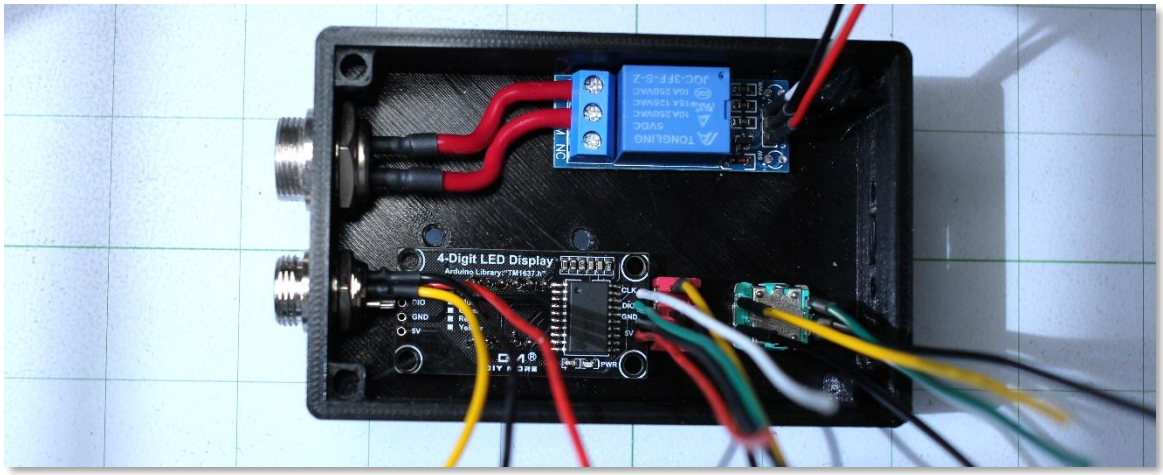


Figure 10

The last two components we will install are the two LED's. The green LED will be used for the "Relay ON" and the red LED will be used for the "Power". Prior to installing, gently bend the two wires at the base of the LED as shown in *figure 15a*. Next, insert both LEDs in the correct positions with the wires positioned approximately as shown in *figure 15b*. Finally, mix a small quantity of "5 minutes" epoxy glue and carefully drop a few beads over the LEDs and the first ½ inch of the wires as shown in *figure 15c*. **Important:** Make sure your project case is perfectly horizontal or the glue will run off. Let the epoxy set completely before moving to the next steps.

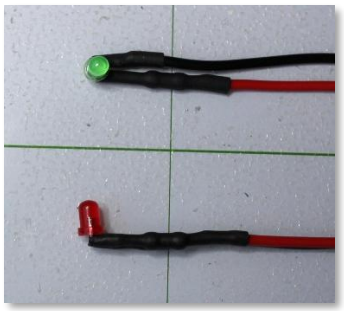


Figure 15a

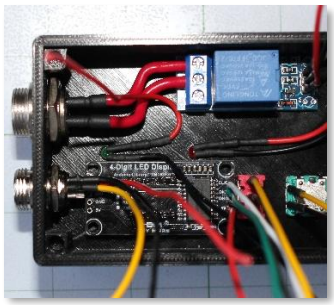


Figure 15b

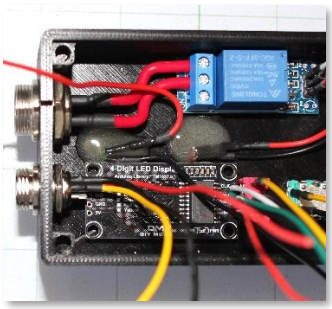


Figure 15c

7. Wiring our Positive and Negative wires

We'll now wire all the positive and negative wires together. Before we do this, cut (2) more 4-inch 22AWG wires, 1 red and 1 black. Starting with the positive wires, gather each of the following wires: 1- the red wire from the relay, 2- the red wire from the GX12 temperature sensor male connector, 3- the red wire from the TM1637 LED display, 4- the red wire from the RED LED and finally, 5- the 4-inch red wire we just cut.

Make sure you do not include the red wire from the green LED as this will be connected later to the microcontroller.

Prior to twisting all these wires together, cut a short ½ inch shrink tube large enough to fit all the wires and slip it over the 5 wires. Using the shrink tube, carefully adjust the wires so that the unconnected cut wire is the same length as the shortest wire, and they are all oriented and positioned as shown in figure 16a. Using wire cutters, cut the wires approximately ½ inch from the shrink tube as shown in figure 16b.

Next, remove the ½ inch shrink tube and remove ½ inch of insulation on each of the 5 wires. Re-install the shrink tube over the 5 wires, and carefully twist all the wires using your fingers. Next, solder the 5 wires and cover them with a protective shrink tube as shown in figure 16c.

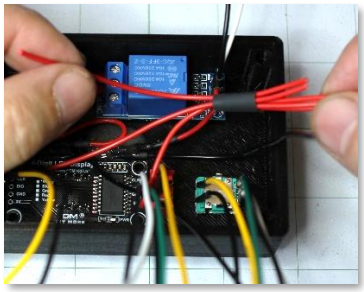


Figure 16a

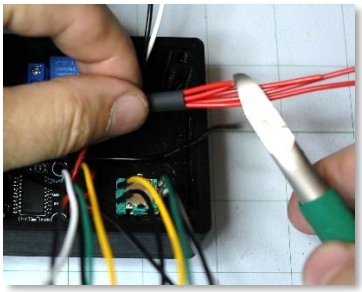


Figure 16b

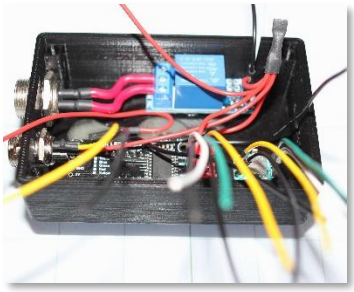


Figure 16c

Next, we are ready to repeat the same process, but this time for the negative wires. So, gather each of the following wires: 1- the black wire from the relay, 2- the black wire from the green LED, 3- the black wire from the red LED, 4 & 5- the two black wires from the rotary encoder, 6- the black wire from the toggle switch, 7- the black wire from the TM1637 LED display, 8- the black wire from the GX12 temperature sensor

male connector, and finally 9- the 4-inch black wire we cut in the first step. That's 9 wires in total, so make sure you have them all. Once again, prior to twisting all these wires together, cut a short ½ inch shrink tube large enough to fit all the wires and slip it over the 9 wires. And now simply repeat the same steps illustrated in figures 16 a, b & c. Make sure the terminal for the red wires is pushed to the bottom of the project case and that the terminal for the black wires is positioned towards the top as shown in figure 17.

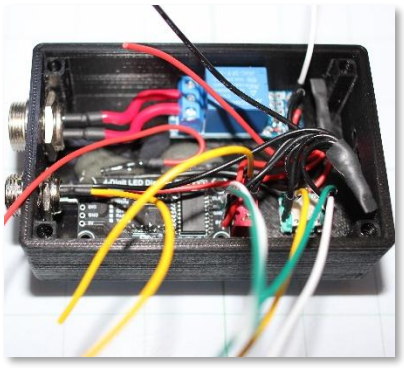


Figure 17

Next, we will secure the USB cable to the project case. Insert the USB cable between the red wires and the black wire from the relay. Once in position, you should be able to align the connector with the hole on the side of the project case. Refer to figure 18 to see how your cable should be correctly positioned.

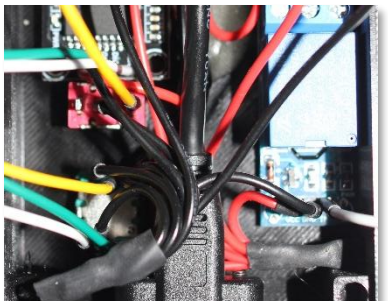


Figure 18

Finally, secure the USB cable to the project case using two M3 x 10 mm hex screws as shown in figure 19. This now completes the first part of the components wiring. In the next step, we will solder the remaining wires to our microcontroller.

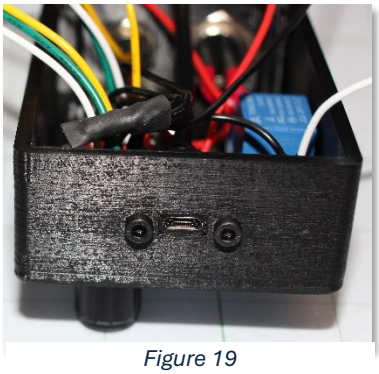


Figure 19

8. Wiring the microcontroller

We will now start soldering each of the remaining wires to our microcontroller. Let's first start with the positive and negative wires coming from the terminal wire bundles. Remove about 1/8 inch of insulation on each wire and solder them to the GRD and 5V pin. Make sure to enter the wires on the top side of the microcontroller as illustrated in figure 20.

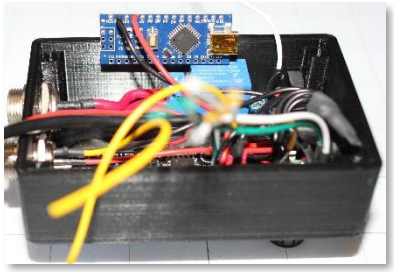


Figure 20

Next, run the three wires from the Rotary Encoder and solder them to the microcontroller as follows: the CLK or (B) white wire to pin 2, the DT or (A) green wire to pin 3, and the switch yellow wire to pin 4 as per the illustration in Figure 21. Use wiring diagram #5 from the course (also included Appendix A) as a reference if unsure of your connections.

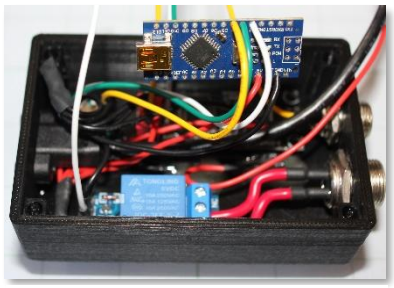


Figure 21

The next wires we will connect are for the toggle switch and the TM1637 LED display. So, connect the yellow wire from the toggle switch to pin 5, the white CLK wire from the TM1637 LED display to pin 6 and finally the green DT wire to pin 7. If some of your wires seem a little long, cut between ¼ to ½ inch off prior to soldering them so they all fit neatly as shown in figure 22.

Figure 22

Let's now wire our last three wires to the microcontroller starting with the yellow data wire from the GX12 temperature sensor male connector to pin 8. Finally, connect the input white wire from the relay module to pin 9 and the remaining red wire from the green LED to pin 10 as shown in figure 23.

Figure 23

9. Installing female connector to Temperature Sensor

In the section, we'll guide you through the process of installing the female GX12 connector to the DS18B20 waterproof temperature sensor. We will also install the required 4.7 K Ohms resistor inside the connector. First cut the 3 wires to a length of ½ inch from the wire sleeve. Then remove 1/8 inch of insulator from each wire. Also cut a 1-inch protective shrink tube which is just large enough to fit over the sleeve. Enter the female connector cover and the shrink tube in the same order as shown in figure 24.

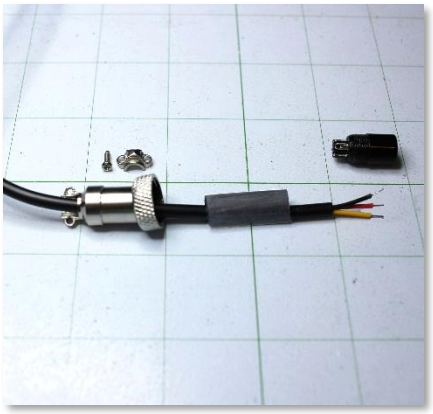


Figure 24

We will be integrating a 4.7 K Ohms resistor inside our connector. We'll need to cut ¼ inch on one side and ½ inch on the other side of the resistor as shown in figure 25a. As we'll be soldering small wires on a very small connector, it will be important to pre-solder both the connector as well as the wires and the resistor as shown in figure 25b. as this will make the next steps much easier to accomplish. Locate pin 1 of your connector (see previous figure 6b) and first solder the short end of the resistor as shown in figure 25c.

Figure 25a

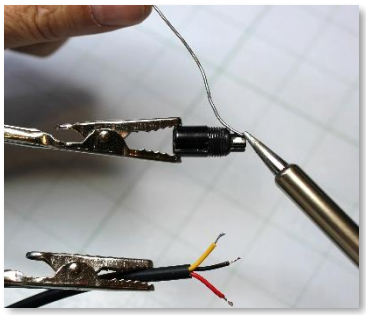


Figure 25b

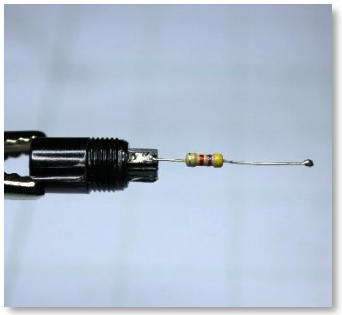


Figure 25c

Next, bend the top of the resistor so that its other end is in contact with pin 3 and solder it in place as shown in figure 25d. We will now solder the three wires to the connector. With the connector cover and shrink tube installed over the wire as per figure 24, first solder the red wire to pin 1 along the already soldered resistor.

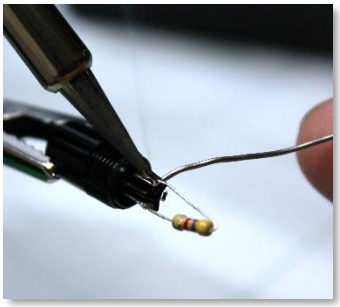


Figure 25d

Next, solder the negative black (or blue) wire to pin 2 and finally the yellow data wire to pin 3 along with the already soldered resistor. Refer to figure 25e for an example of what your soldered connector will look like. Next, slip the shrink tube all the way over the resistor and soldered wire and apply heat to shrink tube so that its nice and tight over the wire and the connector's exposed solder as shown in figure 25f. Finally, carefully screw the connector to the cover making sure that the wire turns loosely inside and then tighten both screws at the neck of the connector as shown in figure 25g.

Figure 25e

Figure 25f

Figure 25g

10. Final assembly & testing

The two last steps we must complete are to properly position and connect the USB cable to the microcontroller as well as insert the (4) larger M3 threaded & knurled brass insert nuts which will help secure our project case cover. Let's first install the brass nuts by loosely inserting them in each of the four holes (pay attention to the orientation as shown in figure 26). With the tip of your hot soldering iron in a perpendicular position to the hole of the nut, apply slight downwards pressure until each of the nuts are flush inside the holes as illustrated in figure 26 & 27.

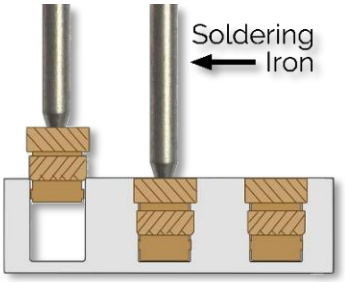


Figure 26

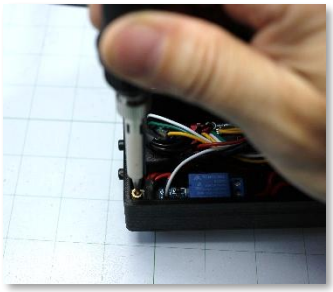


Figure 27

We'll now connect our USB cable to the microprocessor. With one hand, move the microcontroller out of the way, make loop with the USB cable so that it is positioned as shown in figure 28a. While holding the USB cable in place, position the microcontroller inside the project case as shown in figure 28b and connected to the USB cable. Be mindful of your microcontroller being too close to the GX12 connector as it could create a short. If needed, you can put a small piece of electrical tape under the microcontroller to prevent this. Use the project case cover to hold everything in place, and when closing the cover, make sure the wires on the microcontroller are not pressing down on the Nano's reset button.

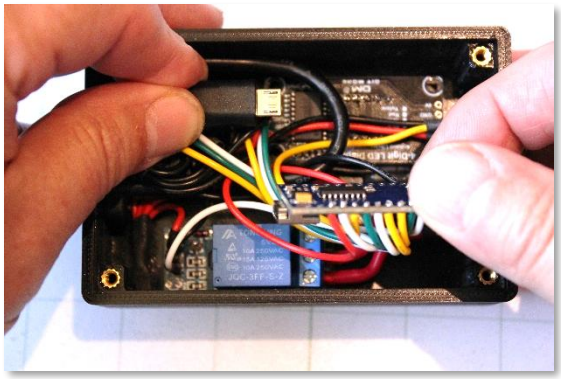


Figure 28a

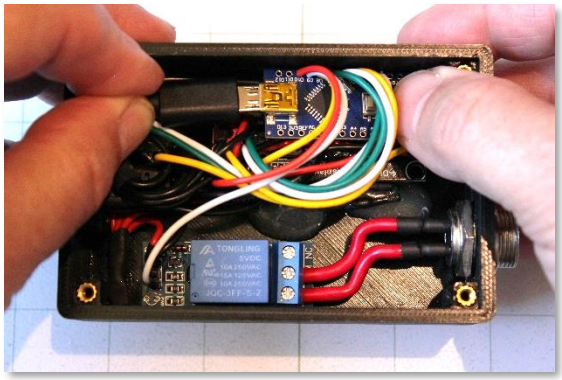


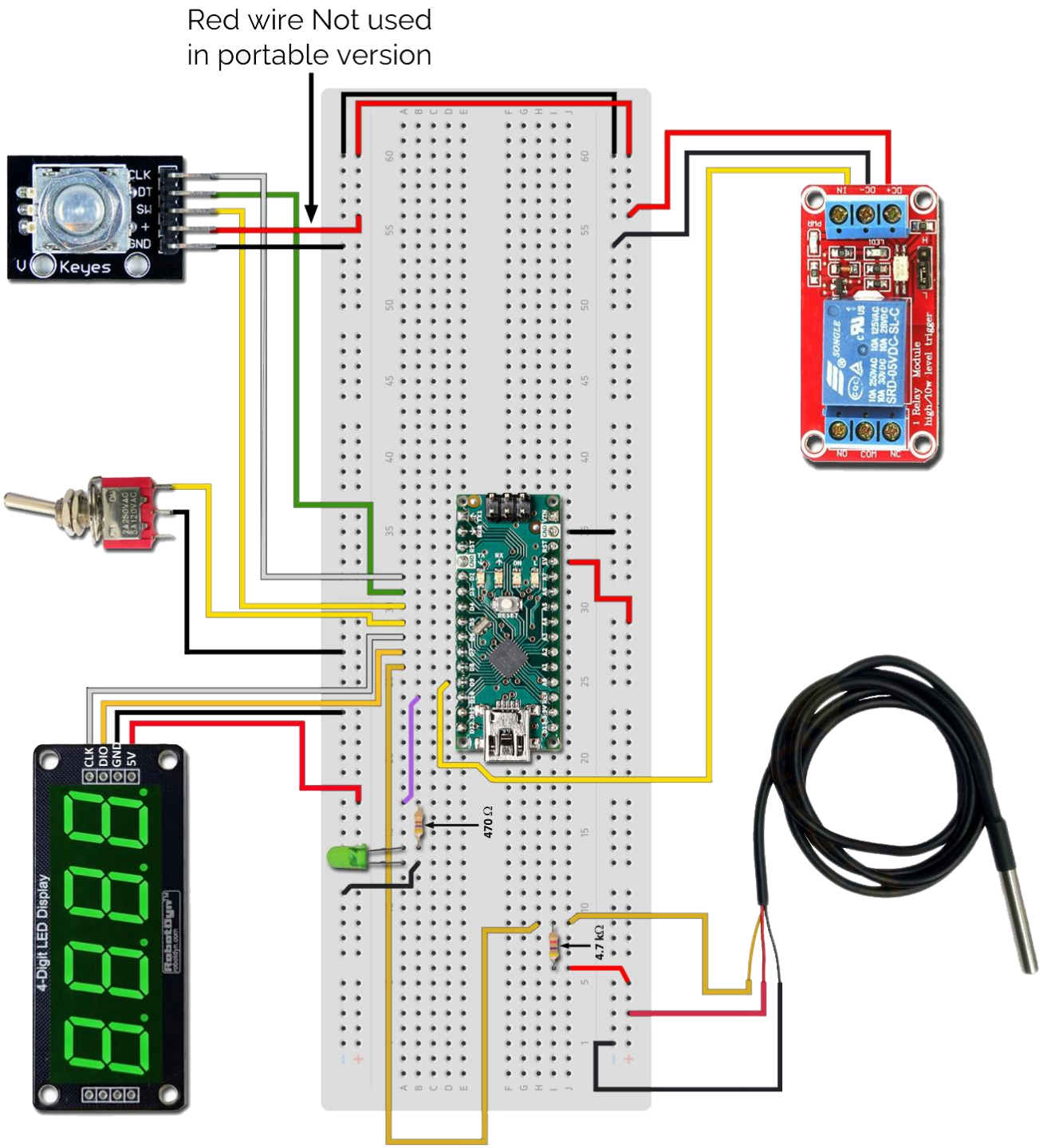
Figure 28b

Once you've secured the cover with the 4 x M3 screws, connect your unit to your computer and upload ATR_v7.ino to your microcontroller. The ATR_v7.ino sketch can be obtained via the link in Appendix B. Once uploaded, disconnect from your computer, and connect your external 5V power supply. Next, connect your temperature probe and the current temperature will be displayed. Now switch your toggle switch to heating mode and do a long press on your trigger temp adjustment button so we can set the high temp. Set your high temp to about 3 degrees higher than your current temperature. Next, do a short press and set your low temp value to around 2 degrees above your current temperature. Your relay should already be on (Green LED), so now hold the temperature sensor between your fingers and once the temperature reaches the high temp value you've just entered, the relay will go off and will only come back on once the temperature lowers below the low temp value you entered.

Congratulations, you have now completed your very own portable Adjustable Thermostatic Relay.

Appendix A

ATR Component Wiring Diagram



Appendix B

ATR Software & Online Course Information

Click on the link below to access the entire course information including all the required software, operations and background information for this project:

https://www.udemy.com/course/arduino-nano-thermostatic-relay-learning-project/?referralCode=747D3FD5730DE0D9AEC2