The Making of RGB Dripping Icicles

by Jim Wright
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Photo 1 - Finished Dripping Icicles

1. **INTRODUCTION:** This document outlines how I designed these RGB Dripping Icicles and some of the decision process that went into that development. This document is intended as a guide only. Your design, thought processes, and requirements may differ. However, it is hoped that this will be of some benefit to the animated lighting community. My thanks to Tim Dorr for some good ideas that were used in the construction of these dripping icicles.

2. **SOME DESIGN CONSIDERATIONS:**

2.1. I wanted to make maximum use of the number of channels in each DMX Universe. This allows us to conserve hardware and software as much as possible.

2.2. I wanted the most flexible design possible. I do not want to limit any capabilities, if it can be avoided.

2.3. I wanted the least expensive solution, based on all other requirements.

2.4. I wanted to maximize the possible distance between directly connected tube segments.

2.5 The dripping icicles system will use DMX interface/protocols.

3. **The Tubes:**

3.1. Refer to Figure 1 on page 4 for a graphic layout design of a tube segment.

3.2. I wanted dripping icicles that were just the right size to be seen from a distance of 30 or more feet. These could hang from trees or anything else for that matter. It was decided that 4 foot long clear plastic tubes would work best. After testing several different sizes, it was determined that a 1 1/4 inch diameter tube would be best. The reasons for that diameter are:

3.2.1. Everything fits inside the tube well, and,

3.2.2. It was a standard size, readily available to us at a reasonable cost.

3.3. After searching for a reliable, readily available source for the tubes, I decided to use a 4 foot Clear Tube Guard, for T8 fluorescent bulbs made by Lithonia Lighting (see Photo 2). These are available from Home Depot at a current cost of $3.47. These tubes are also available at many hardware stores. We also decided that there was no need to apply end caps to either end to the tube, since all of the lights and wiring will be weather resistant anyway. This will also make construction a little easier (fewer steps). There is an exception to this as you will see below.

3.4. I did find an interesting and inexpensive way to hang each tube. The tubes come with plastic end caps (see Photo 2) on both ends. Originally, I decided to discard these caps because I thought that they were not necessary. However, I decided to use one of the caps, as outlined below. This really helped the sturdiness of the design.

Photo 2 - End of Tube With Original Cap

3.4.1. The basic design of the mounting system is simple. I used a metal coat hanger to hang each tube. All you have to do is cut off the hanger and bend it as shown in the picture. The “shoulders” are about 3 inches wide and about 2 1/2 inches deep (see Photos 3 & 4).

3.4.2. Take one of the tube end caps (that came with the tube) and grind the lip off of the center of it. This will allow it to slide into the tube, tightly. Using a glue made for plastic (I used Duco Cement) place a little glue on the outside of the end cap and slide it into the very end of the tube. The top of the ring should be flush with the top of the tube. Allow the glue to set. This acts to reinforce the plastic tube and help keep the plastic tube from tearing itself apart over time. This is the top end of the dripping icicle segment tube (see Photo 5).

3.4.3. Use a PVC pipe end cap to cover the top of the tube and help add rigidity and sturdiness to the hanger/ tube top (see Photo 6).

3.4.4. Place the PVC end cap over the top end of the tube until it is fully seated. This cap will fit loosely around the tube (to allow the wires access to the inside of the tube. Drill a 1/8 inch hole from one side of the cap/tube combination to the other side, straight through the middle. The hole should be just a little below the bottom of the ring that was installed in paragraph 3.4.3, above. This hole will be used to run the horizontal part of the hanger through the tube.

3.4.5 Run the horizontal portion of the coat hanger holder thru the cap and tube combination. Close the hanger by placing the horizontal piece of wire thru the loop and you are done (see Photo 7).

3.4.6. If you wish, you can paint the holder assembly any color you wish to make is less visible, but you don’t have to.

6.4.7. Of course you will have to disassemble this to complete the wiring of the lights, but now it is ready to go.

Photo 3 - Coat Hanger Mount

Photo 4 - Coat Hanger Open

Photo 5 - Original End Cap, Ground Down and Glued Inside the Tube

Photo 6 - PVC End Cap, with Holes

Photo 7 - Completed Hanging Assembly

4. **RGB Lights:**

4.1. I next had to determine what kind of light strings/strips to use in the design. Of course, the first consideration is the visibility of the lights from all directions. It was decided to use light strings, with individual nodes, instead of light strips (rigid or flexible). The light strings can be seen from most any direction (360^{O}) and strips can only be seen from the front (at the most 180^{O}). Strings give the widest viewing angles.

4.2. Next I needed to determine which light strings to use. I had two different string types available to me; the TM1804 and WS2811 chipset strings. Both of these were 12 VDC strings. The 12 VDC strings were used in the belief that there would fewer voltage drop problems with the 12 VDC strings verses the 5 VDC strings. I could use others, but this is what I had available to test. Others might work better; I will be interested to hear if anyone comes up with something better. It should be noted that either of these string types will work based on light output. Therefore, the only real consideration is the maximum distance obtainable from the controller to the first node (communications/timing issue) and between nodes on a string (for extending the length of the string between icicle segments). Of course, you can use “null” nodes (unused nodes) to extend this distance by regenerating the communications signal in the null or unused node. However, we still need to know the maximum distance between nodes. Please note that the design presented here does not use null nodes. However, it would be easy to add null nodes to the design, thus extending the possible distance between the controller and the first real node and/or between icicle segments. That is an issue for another article.

4.3. For testing wiring lengths, I used LOR 3.9.0 software, J1Systems ECG-P2 E1.31 controllers, and 12 VDC strings, not 5 VDC. Other controllers and voltages may give different results. (Note: I have found that a ECG-P2 speed setting of 3000-3200 Kbps for the WS2811 and 2000 Kbps for the TM1804 chip sets works well in our configuration). The testing methodology for wire length to the first node and between nodes was the same. We started with wiring that was obviously too long (30 feet) and cut it down, 1 foot at a time, until all of the lights on a 170 node string functioned properly, with no artifacts or delays. We did use power injection from the back end so that all lights would function once they had a proper data signal. Once we found the proper maximum length, we cut off another foot to allow for some breathing room. The results are below:

1. WS2811 chipset strings. Maximum distance to first node was 8 feet. Maximum distance between nodes was about 7 feet.

2. TM1804 chipset strings. Maximum distance to first node was 18 feet. Maximum distance between nodes was about 17 feet.

d. Therefore, the decision was made to use the TM1804 strings in the RGB dripping icicle design, since these strings offered the longest distance between string segments, without null nodes, or without having to use a controller for each individual segment.

5. **Internal Tube Design** (See Figure 1): I looked at several possibilities for layout of the nodes within each tube. The design being used, I think, provides maximum capabilities in each tube (icicle) segment, the highest resolution within each tube, and the best overall use of resources for each tube “system”.

3.1. Using the TM1804 strings, we will use 32 nodes in each tube. That will completely fill the 4 foot tube and allow 5 tube segments to equal one DMX universe (512 channels) with very little channel wastage (only 10 nodes/30 channels not used; these unused nodes could be used for null nodes if needed). Since each tube of lights is exactly the same, you can use any tube segment in any place in the 5 segment system. It does not matter which tube is used where!

3.2. Data and power will enter on the top, travel thru each node in the tube, in order 1-32 (etc.), and exit via a 3-wire cable that runs back up and out thru the top. This exit wire will connect to the next segment in the DMX Universe.

Photo 8 - String layout

3.2. Each node of the string is folded over so that the tip of the next node just touches the base of the previous node. The node and the associated wire are then held together with a plastic cable tie. (See Photos 8 & 9). This makes a very uniform and compact arrangement. We have our nodes pointing up, but it really doesn’t matter as long as they are all pointing the same direction (so that they will be evenly spaced). As you put the nodes together, make sure that you maintain a straight line for all of the nodes. They will tend to twist if you let them.

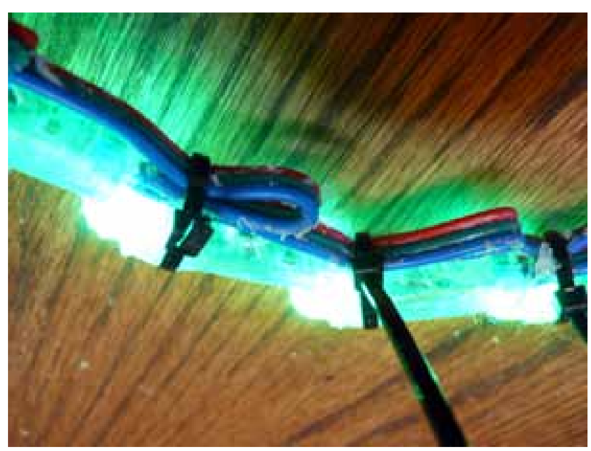
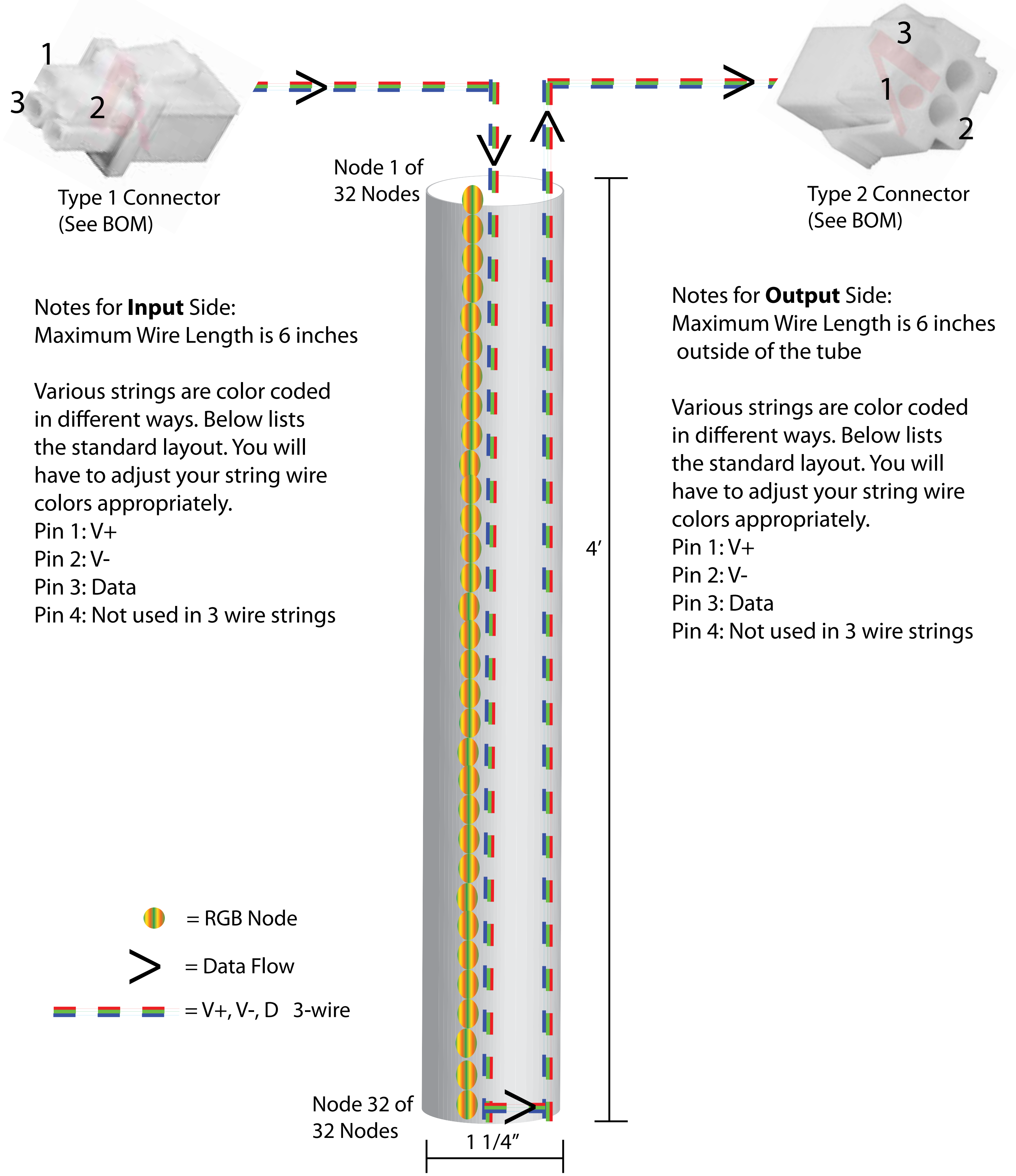


Photo 9 - Close up of 2 Nodes To Show How the Cable is Folded and the Nodes are Tied

1 RGB Dripping Icicle Segment (Tube)



Notes for **Input** Side:
Maximum Wire Length is 6 inches

Various strings are color coded in different ways. Below lists the standard layout. You will have to adjust your string wire colors appropriately.
Pin 1: V+
Pin 2: V-
Pin 3: Data
Pin 4: Not used in 3 wire strings

Notes for **Output** Side:
Maximum Wire Length is 6 inches outside of the tube

Various strings are color coded in different ways. Below lists the standard layout. You will have to adjust your string wire colors appropriately.
Pin 1: V+
Pin 2: V-
Pin 3: Data
Pin 4: Not used in 3 wire strings

Figure 1

6. **Overall System Design**:

6.1. In this design, I have tried to maximize the assets available. In particular I wanted to maximize the number of channels used within each DMX Universe. With 512 channels in each DMX Universe, there are 170 RGB nodes (3 channels each) available in each DMX Universe (with 2 channels left over). Each dripping icicle segment in this design uses 32 nodes (96 channels). Therefore, you can have a maximum of 5 each 32-node segments in each DMX Universe. That leaves only 10 nodes (or 30 channels) unused in each universe. Not bad. And, if you really need it, you can use these 10 nodes as null nodes, although you will have to make that decision before you start your software setup and your sequencing actions.

6.2. This design allows for a maximum of 5 icicle segments from each controller input (1 Universe) although with certain controllers, you can output more than 1 universe from each port.

6.3. For this design, each icicle segment is designed to be independent. There is a data and power input side (Type A Connector) and data and power output side (Type B Connector). Therefore, based on other considerations, you can easily string 5 segments together from one controller output port. You can extend, up to 5 segments, from each controller output port just by connecting the input side of one segment to the output from the previous segment.

6.4. With this design, there are certain distance limitations. Don't forget that these distances are for the TM1804 pixels. Other pixels will use different numbers. Between the controller and the first segment, the maximum distance is 17 feet. The maximum distance between segments, for the extension cables, is 12 feet (17 feet maximum minus 4 feet in the previous controller plus 2 X 6 inches for each segment lead). Staying within this limitation is very important. The system will not work reliably if any of these distances are exceeded. There are other ways of overcoming these limitations (null nodes being one), however, these methods are beyond the scope of this document.

6.5. In order to make the most flexible design possible, we will use connectors on the input and output side of each segment to connect everything together. Then we will use simple extension cords to connect everything together. This segmented design, although a little more work initially, should help greatly reduce actual setup time and problems. And since we are using water resistant connectors, we will have very little down time due to weather related issues.

6.6. A note here about water resistance. The plugs that I used in this "system" are made to be water resistant (not water proof). I always add an additional layer of protection to help ensure that water does not become an issue. I use shrink wrap over the back of each and every connector on to the wire at least an inch or so beyond the connector. In addition, I use shrink wrap with "glue" in it. These two features together help to ensure that, at least at the connector interface, water infiltration does not become an issue. This may seem like overkill, but, so far, I have never had a show failure, or a partial show failure due to water problems with the connectors. That lets me sleep better at night. You can see pictures of this in the photos dealing with the completed wiring.

6.7 Another note about the making of the connectors. The manufacturer states the you don't "have to" solder the pins and wires together after you crimp them. I strongly suggest that you do solder each and every pin to the wire before assembling the connectors. We could put a lot of stress and strain on the wires and connectors in this application. Wind, snow, and particularly ice, could add a lot of weight and strain (pull on the wires) to this system. Soldering the wire to the pin, after crimping, will help to ensure that the wires will not pull out of the pins.

6.8. There is one other major consideration which must be taken into consideration; that of "voltage drop" in long strands of pixels. This problem is more acute in 5 VDC strings than in 12 VDC strings, but there is eventually a point where the voltage will drop low enough that the following nodes will be dimmer than the others, or will not react properly to the commands being sent them. Luckily, there is an easy solution to this issue. The very easy solution is to reinject power towards the end of the string to raise the voltage level back up to acceptable operating levels.

6.8.1. All other things considered, the easiest way to inject additional power is to connect it to the very end of the string. There are two considerations here. First, you must maintain the same polarity of V+ and V-.

Reversing the polarity will cause a short and nothing with work (and may produce a lot of smoke). Second, the power going to the back end of the string must come from the same power supply as the power coming to the front of the string. Do not use separate power supplies for each end of the string. This could also produce major problems and possibly a lot of smoke and ruined hardware. Be aware that you do not want to inject the data signal at the end of the string. Therefore, the power injection cable has only 2 wires and the connectors only have 2 pins (for V+ and V-). This is Cable Type 3 in the drawings.

6.8.2. This design has a very simple fix for this issue. Special pigtail has been designed (See Photo 10). It is inserted just before the first dripping icicle segment (Cable Type 4). Then a long, 2-wire power cable is connected between the two pigtails, thus providing power injection at the end of the string. Also, you can route this power injection cable any way you wish, which may be a shorter distance than from one segment to the next. The length of this cable is not important in this case.

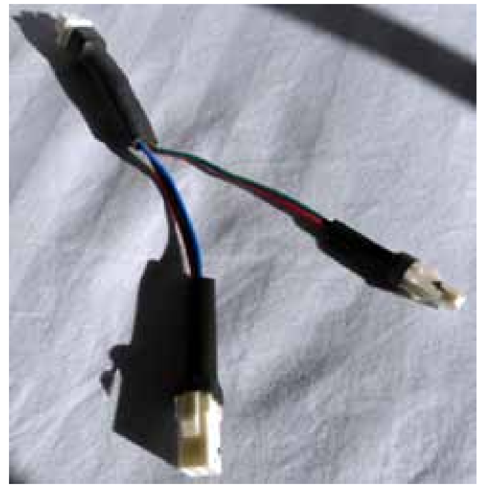


Photo 10 - Power Pigtail, Cable Type 4)

6.8.3. Remember, if you have only 3 or fewer segments connected together, you do not need this added power injection. If you have either 4 or 5 segments wired together, you do need the power injection.

6.10. The extension cables (Cable Type 3) are designed to be placed between icicle segments. If you don't need to separate the segments, then you do not need to use them. The extension cables can be of any length as long as each cable is less than 12 feet long.

6.11. This "system" is designed to be fool-proof. If you install the correct connectors in the correct location, then this modular system will function properly. The 4-pin male connector always "faces" the controller, this is the data input side). The 4-pin female connector always "faces" away from the controller (this is the data output side).

6.12. See Figure 2, on page 10 for a drawing of the entire 5 segment RGB Dripping Icicle design, along with connectors and cables.

6.13. See Photos 11 and 12 for pictures of one completed segment.

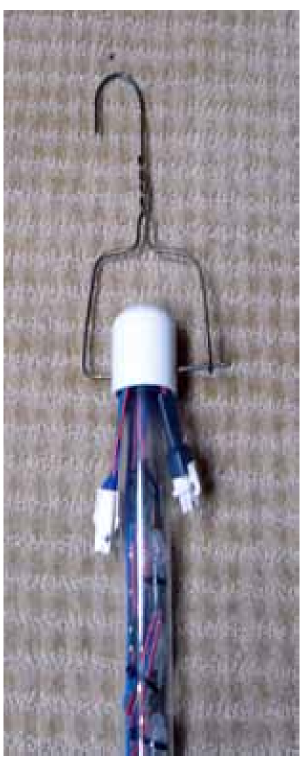


Photo 11 - Close up of Top of a Completed Segment

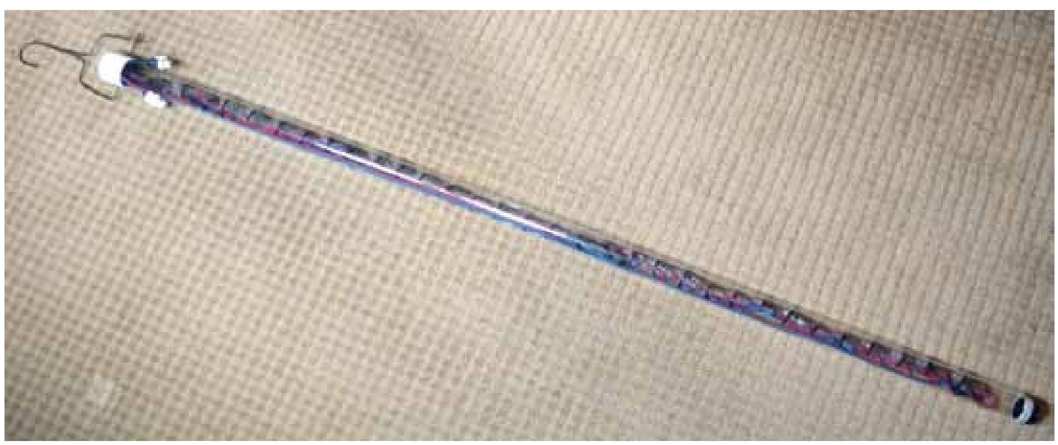


Photo 12 - Completed RGB Dripping Icicle Segment

7. Bill of Materials (BOM).

7.1. You need a total of 160 RGB nodes for this 5 segment set of dripping icicles. For the first set, I used the 128 node LED pixel string; 12 VDC input; TM1804IC, Ray Wu product number 495658226. (one string equals 128 nodes which will make 4 icicles). Therefore, you need to purchase at least 2 of these strings for a complete 5 segment system. (You can use any RGB smart strings that you wish, however, you must adjust all of the wire distances between segments to fit the capabilities of the nodes that you use!)

7.2. 4 foot Clear Tube Guard, for T8 fluorescent bulbs made by Lithonia Lighting. These are available from Home Depot or most hardware stores. Any other appropriate sized plastic tube will work. You need 1 tube for each dripping icicle segment that you make. (5 tubes for one complete 5 segment system.)

7.3. 1 1/4 inch PVC end cap (such as used for dead-end plumbing). You need 1 end cap for the top of each dripping icicle segment that you make. (5 caps for one 5 segment system.)

7.4. Metal coat hanger or other device for mounting each dripping icicle. You need 1 mounting hanger for each dripping icicle segment that you make. (5 hangers for one 5 segment system.)

7.5. Plastic cable ties (to bind the folded nodes together. Any cable tie will work. I used ties made by Hellerman Tyton, part number 111-02315, available from Allied Electronics. (Minimum of 160, but buy more for extra needs.)

7.6. 1 tube of glue that will work for plastic (I used Duco Cement, available in most hardware stores.)

7.7. Enough 3 conductor wire, the same as used in the light strings, for all of the internal and external wiring needs. For the entire 5 segment system discussed here you need at about 150 feet of 3 strand RGB type wire. This is the cable from Ray Wu's store: "100m/lot; 3pin cable for RGB color led strip&module, 20AWG, 100m long".

7.8. Connector Hardware: (You can use any connector hardware you wish, or hard-wire between each segment. This is what I used. The connectors are made by AMP/TYCO Electronics and available from Allied Electronics, among others.) These connectors are water resistant, not water proof. I also use shrink wrap tubing over the back end of the connectors on to the wire to aid in the water resistance.

7.8.1. For each male 4-pin connector you need (input of each segment) (**Plug Type A**):

7.8.1.1. 1 each "Connector; Nylon (Housing); 4; White; RoHS Compliant, ELV Compliant", 4 pin plug, part number 794805-1.

7.8.1.2. 3 each "Connector; Pin; Brass; Pre-Tin; 600 VAC; 9.5 A; 22 to 18 AWG, 22 AWG; 0.039 in." male pins, part number 770987-1. (Note: You will need 4 each pins if your strings are 4-wire and not 3-wire.)

7.8.1.3. 3 each "Connector; Silicon Rubber; Blue; 26 to 18 AWG; 0.043 to 0.083 in." seals, part number 794758-1. These help provide the water resistance.

7.8.1.4. 1 each "Connector; Silicon Rubber; Black; RoHS Compliant, ELV Compliant" plug, part number 794995-1. This seals the hole in the connector that is not used by wires (Note: You do not need this seal if you are using a 4-wire string.)

7.8.1.5. 1 each "Connector; Urethane Foam; 4; RoHS Compliant, ELV Compliant" gasket, part number 794772-4.

7.8.2. For each female 4-pin connector you need (output of each segment) (**Plug Type B**):

7.8.2.1. 1 each "Connector; Nylon (Housing); 4; Natural; RoHS Compliant, ELV Compliant", 4 pin receptacle, part number 794939-1.

7.8.2.2. 3 each "Connector; Socket; Brass; Pre-Tin; 600 VAC; 9.5 A; 22 to 18 AWG, 22 AWG, female pins, part number 770988-1. (Note: You will need 4 each pins if your strings are 4-wire and not 3-wire.)

7.8.2.3. 3 each "Connector; Silicon Rubber; Blue; 26 to 18 AWG; 0.043 to 0.083 in." seals, part number 794758-1. These help provide the water resistance.

7.8.2.4. 1 each "Connector; Silicon Rubber; Black; RoHS Compliant, ELV Compliant" plug, part number 794995-1. This seals the hole in the connector that is not used by wires (Note: You do not need this seal if you are using a 4-wire string.)

7.8.3. For each Male 2-pin connector you need (for power extension) (**Plug Type C**):

7.8.3.1. 1 each "Connector; Nylon (Housing); 2; White; RoHS Compliant, ELV Compliant " 2 pin plug, part number 794894-1.

7.8.3.2. 2 each "Connector; Pin; Brass; Pre-Tin; 600 VAC; 9.5 A; 22 to 18 AWG, 22 AWG; 0.039 in." male pins, part number 770987-1. (Note: Same as in 7.8.1.2, above)

7.8.3.3. 2 each "Connector; Silicon Rubber; Blue; 26 to 18 AWG; 0.043 to 0.083 in." seals, part number 794758-1. These help provide the water resistance. (Note: same as in 7.8.1.3., above.)

7.8.3.4. 1 each "Connector; Urethane Foam; 2; RoHS Compliant, ELV Compliant" gasket, part number 794772-2.

7.8.4. For each Female 2-pin connector you need (for power extension) (**Plug Type D**):

7.8.4.1. 1 each " Connector; Nylon (Housing); 2; Natural; RoHS Compliant, ELV Compliant" 2 pin receptacle, part number 794896-1.

7.8.4.2. 2 each "Connector; Socket; Brass; Pre-Tin; 600 VAC; 9.5 A; 22 to 18 AWG, 22 AWG, female pins, part number 770988-1. (Note: same as in 7.8.2.2, above).

7.8.4.3. 2 each "Connector; Silicon Rubber; Blue; 26 to 18 AWG; 0.043 to 0.083 in." seals, part number 794758-1. These help provide the water resistance. (Note: same as in 7.8.1.3., above.)

7.8.5. Connector recap. The following table shows how many connectors of each type that you need to make the complete system. I suggest ordering at least 10% more.

Part	# Type A	# Type B	# Type C	#Type D	# Items In System	Total Type A Needed	Total Type B Needed	Total Type C Needed	Total Type D Needed
Icicle Segment	1	1	0	0	5	5	5	0	0
Cable 1	0	1	0	0	1	0	1	0	0
Cable 2	1	1	0	0	4	4	4	0	0
Cable 3	1	0	1	0	1	1	0	1	0
Cable 4	1	1	0	1	1	1	1	0	1
TOTAL						11	11	1	1

7.8.6. If you make the entire 5 segment system as designed, with all extensions, you will, as a minimum need the following connector parts (you should add some additional pieces when you order since, if you are like me, you will damage or loose a few of the parts. I suggest at least 10% more.

Connector Part Name	Part Number	Minimum Quantity Needed
4 Pin Plug (Type A)	794805-1	11
Male Pins for all connectors	770987-1	35
Blue Rubber Wire Seals for 4 pin plug for all connectors	794758-1	39
Black Rubber Seal for all 4 pin connectors	794995-1	22
Gasket For 4 Pin Plug	794772-4	11
4 Pin Receptacle (Type B)	794939-1	11
Female Pins for all connectors	770988-1	39
2 Pin Plug (Type C)	794894-1	1
Seals For 2 Pin Plug	794758-1	1
2 Pin Receptacle (Type D)	794896-1	1

7.9. Shrink Wrap. I use EPS-300 Adhesive Line, 3:1 Flexible Polyolefin Heast Shrink Tubing from 3M. I order it from Allied Electronics. The part number for the 3/4 inch tubes is 70234432. The part number for the 1/2 inch tubes is 70234427.

7.10. Speciality Tools. Using this design you will need two special tools. If you already have them, great.

7.10.1. A crimping tool for the pins used in the connectors.

7.10.2. A head gun for the shrink tubing. I use a 1200 watt heat gun from Paladin Tools, but any reasonable heat gun will work.

8. I have endevored to be as accurate as possible in this document. However, errors can creap in. Please use this document as a guide only. If you find any errors, or if you have any comments, I welcome them. You can e-mail me at jimwright@kc.rr.com.

9. Enjoy!

Figure 2 - The Entire 5 Segment RGB Dripping Icicle System