Animated Lighting 101
Version 1.2

www.HolidayCoro.com

This document covers the major steps in setting up a display of animated Christmas lights. The document is also written with some minor assumptions, which are:

- You have reasonable computer skills
- Designed for a small sized display - under 32 channels
- Less than 10,000 incandescent or 50,000 LED mini lights

1. **Should I even build a display?**
    a. Here are some of the negative issues that you should be aware of prior to building a display:
        i. Depending on location and publicity factors, your display may become large enough to create the following problems:
            1. Traffic issues
            2. Trash
            3. Damaged lawns (yours and/or your neighbors)
            4. Theft of your display elements
            5. Angry neighbors (from display related issues – too loud)
            6. Possible issues with your spouse due to the time and money spent
        ii. The amount of time to assemble a display from the ground up can take hundreds of hours which include:
            1. Spending 2-5 hours programming the lights for each minute of music
            2. Spending many hours on holiday lighting forums reading about issues you will encounter or problems you are having
            3. Dozens to hundreds of hours erecting, removing and fixing your display
            4. You are limited as a result of your display from travel or other events in order to "manage" your display. This may include directing traffic, fixing bulbs or replacing damaged/stolen items.
        iii. Costs
            1. It is easy to forget the "true" cost of a display which include costs for items such as:
                a. Dedicated computer to run your display
                b. Software to program the display
                c. Controller cables and related
                d. Hundreds to thousands of feet of extension cords

e. Thousands and thousands of lights
f. Display elements such as mega trees, cutouts, inflatable's, blow molds, etc
g. A location to store your display off-season

b. Here are some of the positive issues of building a display:
   i. Some neighbors join in and have a sense of community as a result of the display
   ii. Kids love it
   iii. It's more productive than watching football
   iv. You get to be "the man" in the neighborhood (as it were)
   v. For techie people, it allows you to explore your inter-nerd

2. Basic Animated Lighting Terminology

a. The following is a list of common terms you may hear in reference to building an animated light display. This list is not comprehensive but should provide the basics necessary to complete the steps further on in this process.
   i. **Static Display** – A display in which lights are turned on and not synchronized together.
   ii. **Animated Display** – A display in which lights are typically synchronized to music. This can also mean that the lights are simply animated without music.
   iii. **(Lighting) Controller** – This is a device that can perform three actions, turning on, off or diming a light or lights attached to it.
   iv. **Channel(s)** – Each controller can control a number of channels. Typically this amount is 8 or 16 channels. Each channel can control a light or lights attached to it. That light could be a single 100 watt flood light; it could be 10 strings of mini-lights or even strobe lights. There is a limit to the number of lights can be controlled by a single channel and there is also a limit to the total amount of lights controlled by a single controller – these limits will be discussed further in this document.
   v. **Dedicated Power Circuit** – In a typical house, common power outlets are grouped together – those in the bathroom, those in the kitchen or those in the garage. Many outlets all share a single "dedicated circuit" within the electrical panel protected by a circuit breaker. In most modern houses these are 15 amp circuits.

3. Don't Buy Anything! No, really – don't buy anything yet!

a. If you've decided to build a display, resist the temptation to start buying **anything**. The absolute first step in building a display is planning!

b. Planning your display
   i. First you need to start by defining what area(s) of your home you want to build your display on. Start by standing in front of your home from the point of view of the intended traffic, usually in the street. This will give you an idea of what your audience will see – you may even want to be in the car as cars often limit the viewing angle of your display (such as 2nd story roof lights). Make note of the following:

1. Trees, landscaping, fences or any other items that may obscure the view of your home or other elements you may want in your display. For example – if you have a two story house close to the street, the roof line may not be very visible. You may have a large oak tree that doesn't lose all its leaves in the winter.
2. Possible areas for elements in your display could include windows, columns, flower beds, trees, empty yard space, fence, sidewalks, driveways.
3. How close elements can be in the display to the viewing location.

ii. Take photo(s) of your home that include the entire area you intend to build your display in. These will be used later as a template for determining where to place your lighting and other elements. Print out five or more copies of this photo as large as possible – this will serve as your template for "virtually" laying out your display.

iii. Make a budget of the most you are willing to spend, out of pocket, for your display. You can expect to spend more than even your best guess, so plan for that.

iv. Make an inventory of any lights or elements you currently have "in stock" for your current static display that you may want to include in your new display.

v. Purchase a multi-color set of crayola markers to mark-up the photos of your display area taken previously.

c. Determine what elements can be in your display and still be within the financial and power budget.

i. The next part is a little tricky – there are a number of factors that ultimately control the number and type of elements in your display, they are:

1. Electrical load required by the lights
2. Your budget
3. Your current inventory of lights and display elements
4. The amount of free time you have

ii. Power

1. Outside the overall cost of the display, the most important issue to focus on when planning a display is the amount of power it could consume. There are two major factors that affect power consumption:

a. **LED vs. Incandescent (traditional) lights**. For example, an a string of 25 LED C9 bulbs consumes about 2.4 watts, a string of 25 C9 incandescent bulbs consumes 175 watts – quite a significant difference! Of course there is no free lunch – there wouldn't be incandescent lights if the cost of LEDs were not 2-5 times more than incandescent lights of the same type. Of course, over time LEDs may become as cheap as incandescent but that day is not here yet (2009). So, while the cost of incandescent lights is initially cheaper, they will cost more to

operate (power) and will require more infrastructure (more and thicker gauge extension cords, more controller channels, etc).

b. **The number of lights installed**. Of course as you add more lights, the amount of power they consume – LED or incandescent, will go up.

2. There are some basic "break points" at where power transitions from a non-issue to a major issue and those are determined by the number of close, available dedicated power circuits. For example, you may have a power plug on the outside of your house, shared among all outside power outlets. You then may also have additional circuits in your bedroom near the front yard where your display is located. Once you determine which of these circuits can be "dedicated" to your Christmas lights, you now know the maximum power you have available to run your display. An example of the number of lights that can be run using a common 15amp circuits is shown below:
    a. One 15amp circuit:
        i. 45,000 LED Mini Lights or
        ii. 4,800 Incandescent Mini Lights
    b. Two 15 amp circuits:
        i. 90,000 LED Mini Lights or
        ii. 9,600 Incandescent Mini Lights
3. As you can see, there are some pretty large differences between in the quantity of lights that can be run from just a few outlets. The main thing to be aware of here is that once you move beyond just the localized, dedicated outlets near your display, bringing additional power to your display will start to become a serious concern.
4. As each home and display is different, extending additional power to your display could cost as little as a few hundred to a thousand or more dollars depending on the load, the distance from the power source and your skills to implement the solution.
5. It would be recommended staying within the two outlet power requirement for your first display.
6. To calculate the amount of power for your display, you can use pre-made spreadsheets such as the "Controller Calculator" located here: http://www.quartzhillchristmas.com/12.html

iii. Display Elements and Lights

1. Now that you've determined how much power you can supply to your display, which will drive the number of lights and power consuming display elements you can use, you can start laying out your lights and elements.

2. It is recommended that you start by looking on YouTube.com, Vimeo.com and other video sites on the internet for ideas as to what types of elements you will use. Examples of common elements are:
    a. Leaping Arches
        i. A pipe lined with segments of lights that are individually controlled.
    b. MegaTrees
        i. A large (usually 10ft tall or more) “virtual” Christmas tree made from pipe and strings of lights. Most often each “slice” of the tree is controlled separately.
    c. MiniTrees/CoroTrees
        i. Small little “trees” with lights wrapped around them. The structure is commonly made from wire and they are about 2-3ft tall. Normally only one or two colors per tree.
    d. Blowmolds
        i. Plastic 3D shapes that are internally lit in shapes such as santa, elfs, candles, reindeer, etc.
    e. Inflatable’s
        i. 3D plastic fabric inflated with a air blower to form the shape of a character or other common element. Typically internally lit with lights though also lit with flood lights.
    f. Cutouts
        i. 2D plastic or wood cutouts in the shape of characters, usually lit with front mounted flood lights though also commonly have lights attached to the display.
    g. Wireframes
        i. 2D or 3D metal wire frames that are lined with lights in the shape of a character.
    h. Light Outlines
        i. Lengths of light along architectural elements such as roof lines, sidewalks, windows and doors.
    i. Light Wrapping
        i. Wrapping of lights around objects, most commonly around trees or columns.
    j. Net Lighting
        i. Light strings that form an X/Y grid to cover items such as bushes or walls.
    k. Flood/Wall Wash Lighting

i. Flood lights or LED lighting that is used to "wash" an entire wall or surface in a given color of light. Commonly used on fences and house walls.

l. Driveway and side walk arches

i. Arches placed over a sidewalk or driveway, normally covered in lights.

3. As you can see, there are a lot of different elements that can be used in a display. There is no one right or wrong combination of elements to use in your display. By viewing other people's displays, you will be able to better determine what works well for you and your display.
4. Once you have a good idea of what types of elements you want to use, use the printout of the photo you took of your display area. Using that printout and the colored markers, start marking on the photo with different colors to represent different elements of your display – lights along a roof, a leaping arch, a mega tree, etc. You may also find it useful to measure your yard to determine spacing of the elements – for example, a common sized leaping arch is as much as 15ft long, so if you have a yard that is only 50ft wide, it could be a little tight to put in three arches, blow molds and a few cutouts and still clearly see all the elements. Make several versions until you can visualize your completed design.

iv. Controller Channels

1. Controller basics

a. There are two types of controllers:

i. "Do It Yourself" controllers that you build and assemble yourself, such as the Lynx Express from www.diylightanimation.com . They have the advantage of being very inexpensive but you need to have a reasonable level of skill with electronics and some patience.

ii. Commercial controllers that you purchase off the shelf. The two primary vendors that are both compatible with each other are d-Light (www.d-light.us) and Light-O-Rama (www.lightorama.com). Both of these vendors sell different "levels" of controllers – from solder together kits (silver or hobbyist) to out-of-the-box and working in minutes controllers (gold or showtime). Common prices are:

1. DIY Kits without enclosures - $6 per channel
2. Solder together kits without enclosures - $9 per channel
3. Partially assembled kits - $13 per channel

4. Complete, ready-out-of-the-box - $22 per channel
5. More details on the different types of controllers can be found here: http://www.holidaycoro.com/2010LSHWorkshop

iii. Typically, each controller will handle up to 7amps of power per channel and 8 channels share a single power feed of 15amps. So, this means that you could run 7 amps on two channels, one amp on the third and the remaining 5 could not be used. Or, in a balanced system, power would be split equally among all the channels, such as 1.8amps per channel.

b. Controllers also need the following items to be functional:
   i. Computer to run the controllers – Used or new
   ii. Computer to controller Interface (USB to 485 adapter) - Usually about $30
   iii. Signal cable (usually just regular computer network cable or "cat 5") – Usually 20 cents or less per ft (www.monoprice.com)
   iv. Software to program the sequences and run the controllers - $50 to $140

v. Calculating Power Consumption
   1. If you are not running LED lighting, it is important to determine how much power you will be consuming. So, this all starts with figuring out how much power each strand or individual lights consume. As you have always determined where the lights will be located, you simply need to add all of these string and lights up. These amounts will then be added together to determine the number of channels and placement of lights on specific channels to balance the load.
   2. There are some rules-of-thumb for lights, they are:
      a. C7 Light – 5 watts
      b. C9 Light – 7 watts
      c. 100 mini lights – 40 watts
      d. 100 LED mini lights – 5 watts
   3. It is recommended that you purchase samples or test your existing lights you plan to use for exact numbers as these amounts can vary for manufacturer to manufacturer. The best tool for measuring the power consumption of your lights is using a device called a kill-a-watt (www.p3international.com/products/special/P4400/P4400-CE.html)
   4. Enter all these wattage amounts for the different lights into your spreadsheet.

vi. Now that you have your elements laid out, it's time to see if they fit within your power and cost budgets. For each element you will need to determine how many channels of individually controllable lighting you want. For example, a leaping arch would commonly have eight or more channels/segments. Common areas to look for when counting the number of channels is:
    1. Windows – is each window in a separate channel? Will there be more than one color in each window?
    2. Edge/sidewalk lights – is each side of your house on a separate channel? Is there more than one "layer" of color?
    3. Arches – how many segments? More segments means smoother movement at additional construction and controller costs.
    4. Roof/Gutters – is each section of your roof line on a separate channel? How many colors do you want to have layered?
    5. Flood lights – how many flood lights will it take to cover the entire house? Will there be more than one color?
    6. MegaTree - how many colors? How many sections/slices will the tree have?
    7. Misc Elements – strobe lights, blow molds, wire frames, signs, etc. Each of these elements needs to be calculated into the total number of channels required.

vii. So, now you should have an idea of how many individually controllable channels you will have. A rule of thumb for "cost per channel" for a typical 2,500sq/ft home with a 5,000 sq/ft yard is about $20-40 per channel. Of that amount per channel, about $15 is for the controller itself and the remainder is for signal/power wiring, mounts or boxes for the controller and extension cords to and from the controller. Of course this number depends on a variety of factors. If the controller placed at or very near the display element, which is less secure, requires longer/heavier power cable but doesn't require any or requires fewer light cord extensions. Common examples of where you would place a controller next to a display element are megatrees and leaping arches. You might place a controller back in your bushes near your home and run extension cords to the display elements, such as blow molds, strobe lights, minitrees, flood lights, etc.

viii. Another important factor in determining the number of channels is power consumption. If you are running LED's this rarely is of a concern but if you are running incandescent lights, you will need to closely track the number of lights or other elements placed on each channel. For example, you may want to use 7W, C9 bulbs and you discover that you need 300 C9 lights to outline your roof on a single channel. The total consumption of those 300 lights would be 8.75amps on a single channel which is over the typical limit of 7amps per channel. The other problem is that since most controllers are limited to 15-

20amps per bank of 8 channels that would leave less than half of the power for the remaining seven channels.

ix. Take all this information on lights per channel and enter it into the previously referenced spreadsheet. Work to keep the amounts under the limits, even if this means moving items to different controllers.

x. At this point, you should now know how many lights, the power they consume, your overall power consumption and the number of channels/controllers you require.

d. Power Distribution

i. If the total power input for the controller is above the number of dedicated power outlets available to your display, you will need to investigate how to get additional power to the display, usually at high expenses or reduce the number of lights within your display. Check with experienced display builders on what solutions maybe available to you.

e. Wall Outlet to Controller Power

i. Wire in extension cords is listed in gauge, AWG or "ga". The lightest extension cord you want to use is 14 gauge. As the thickness and increased power carrying capacity increases, the gauge decreases, so, 12ga is able to handle more power than 14ga. When in doubt – just purchase 12ga extension cords. Also recommended are cords with power light indicators in their ends so you can be sure there is power to a controller.

ii. Most controllers are comprised of 16 channels. Those 16 channels are split into two "banks" of 8 each. Each bank can handle 15-20 amps, providing a total of 30-40 amps of power control. Normally, each controller has two male plugs. If you have any single bank over, say, 15amps, you will then need to run TWO separate cords from TWO dedicated power outlets (NOT the same Wall Outlet) to the controller. Conversely, if you have a controller that has a total power draw of only 7 amps total for both banks, both banks could be plugged into the same extension cord and then plugged into the same dedicated outlet.

f. Controller to Lights Power

i. Since each individual channel generally uses less power than the entire controller itself, you can use lighter gauge (less capacity) wire for your lights and display elements.

ii. Do not purchase pre-made extension cords – they will not be the right length and they are generally expensive.

iii. Most outdoor displays extensions are made from "SPT" wire. SPT wire is also known as "lamp cord" – it is two wires encased in a flat ribbon of plastic. There are two common grades of SPT wire, SPT1 and SPT2. SPT1 can carry 7amps of power and SPT2 can carry 10amps of power.

iv. Making extension cords out of SPT wire is quick and easy. First, purchase the necessary amount of wire in the size you need. The best deals are on the 1000ft rolls of wire, though smaller lengths can be found at the hardware store. A

1000ft roll of SPT2 wire will generally run $110 when ordered on-line or as much as twice that when purchased at the hardware store.

v. Next, you will need to purchase male and female plugs for the type of wire you are using. This is where it is good to "standardize" on a single type of wire – if you will need any SPT2, just always purchase SP2 even if you only need the lighter SPT1. Plugs run about $1 or less each and depend on where and when they are purchased. The female plugs can be installed anywhere along the line if needed and more than one plug can be installed on the wire. Check the internet for instructions on how to install these plugs

g. Programming

i. By this point, you have completed the "infrastructure" portion of your display. Once the infrastructure (lights and elements) are just the way you like it, you can start programming your lights.

ii. Programming starts with software. There are several programs for Windows PC's that can accomplish this goal, they are:

1. Light-O-Rama – the "orginal" commercial software for controlling Christmas lights. It is a simple, well documented, stable application. It generally lags behind other applications in terms of features. Will control Light-O-Rama and d-Light controllers.
2. Light-Show-Pro – A newer application released in the summer of 2009 that is "cutting edge" though at the time of this writing, it does not have a large installed base of users and is still undergoing some growing pains (bugs). Will control Light-O-Rama, d-Light controllers and other "do it yourself" controllers.
3. Aurora

iii. All of the above applications share the same basic functionality - the ability to time turning on/off/dimming of lights in sequence with music. This intro does not directly cover the methods used to program the lights – please refer to other documents on how this process occurs based on the application you are using.

iv. You can expect to spend about 2-5 hours PER minute of music programming the lighting. This number varies depending on your skill, the quality of the finished product and the complexity and the number of channels you have to program.

v. Once your programming is complete, you will end up with a "sequence". This sequence will then be put into a "show" that is comprised of other sequences. This show will then be scheduled and run from the computer. This requires that you leave on your computer, generally dedicated to this function, to run your light show.

vi. The signal from the PC will be converted from USB to a two-wire communications system called RS-485 adapter. These signals will be sent over either ordinary phone wire or more commonly, network cable which is widely

available. This cable will go daisy-chain from the first controller to the second to the third and so-on.

vii. Each controller has a separate “address” much in the same way each house on a street has a separate address. When you program your lights, you will indicate to the software that you want controller 2, channel 5 to turn on. The signal will be sent to all controllers and only channel 5 on controller 2 will turn on.

h. Audio

i. Of course, what good would lights that are sequenced to music be if you could not hear the music that they are sequenced to? This generally means that you need two things: Speakers and a radio broadcasting system

ii. Speakers – It is common for a set of low power speakers to be placed in the yard so that people on foot or people who are not in their cars can hear the music from the display. You can use anything from simple computer speakers to fancy outdoor speakers.

iii. Radio Broadcast – The FCC allows people to run very low-power “radio stations” that generally only broadcast for 1-2 blocks. The radio transmitters send the signal from your computer to a frequency you select and the display on a sign in your yard. This allows people in cars to hear the display without getting out into the cold. Radios and the antennas can run from $150 to several hundred dollars depending on the power and features.