INSTRUCTIONS

Audio Sources: The controller's audio input is a 3mm (1/8") stereo male plug. Just about any audio source can be used, including the "record" or "line" output of a stereo or the headphone jack of a music player, cell phone or tablet. Generally, a Y-cable is needed to split the signal between the color organ and a boom box or stereo because plugging into a phone or tablet's earphone jack disables its internal speaker. A Bluetooth receiver "dongle" paired to the cell phone or tablet can also be used, although the Y-cable is still needed to split the audio signal since Bluetooth devices operate only in pairs.

A boom box or stereo with an audio input is necessary because Bluetooth introduces a delay, so a second Bluetooth link behind the Y-cable would make the color organ appear to respond to music before you heard it.

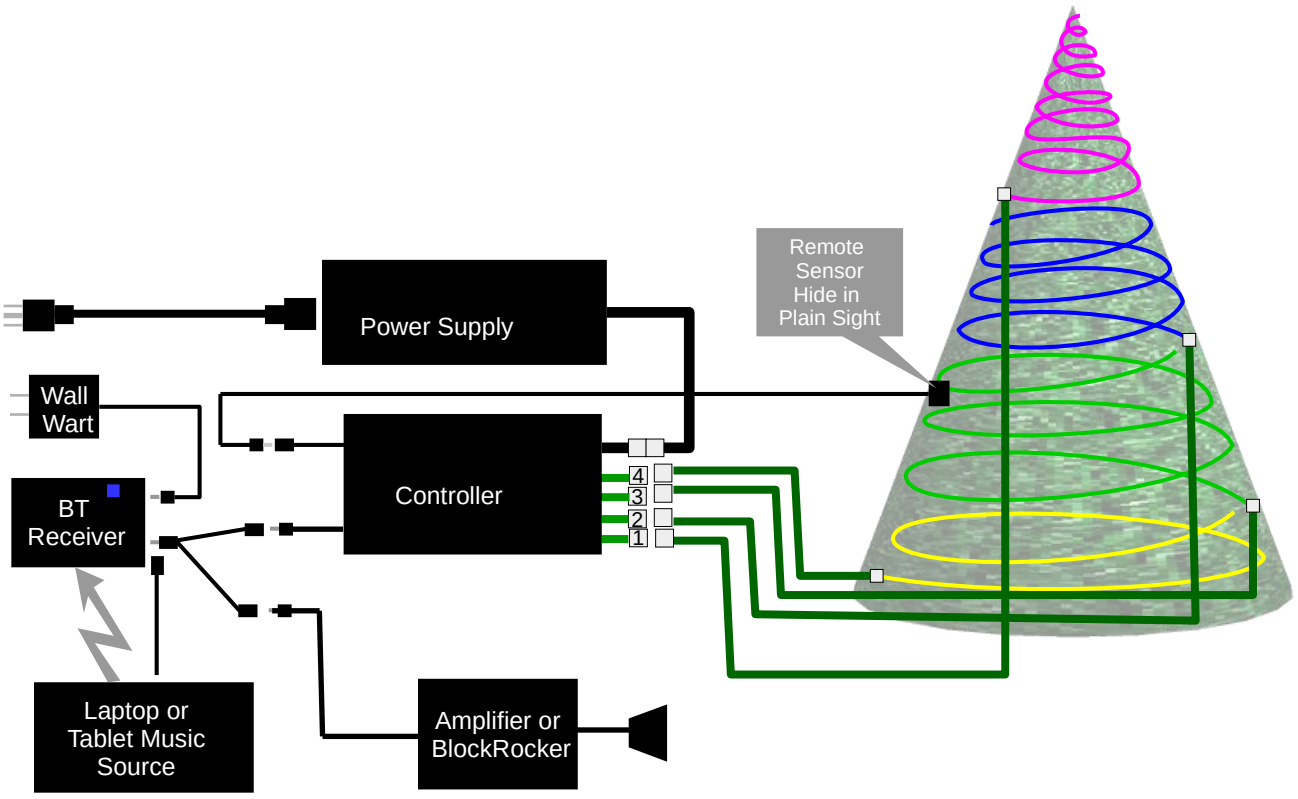
Remote Control: The IR sensor is a small black dongle on the end of a black 4' cord that plugs into 3mm (1/8") female jack on the controller. Its lens is a bubble on one side of the dongle, which can be hidden in plain sight as long as the lens roughly faces the remote.

LED Strings: The four LED strings are identical and interchangeable. Although the strings have a green connector at each end, the wire is much too thin for them to be daisy chained. They must be individually connected to the controller at the end with the white connector. The four connectors on the controller are numbered 1 through 4 corresponding from top to bottom of a Christmas Tree

The green cords are electrically interchangeable, but are different 5', 7', 8' and 10' lengths to reach from the bottom to the top of a Christmas tree.

Christmas Tree Use/Trimming Tips:

For a proper rainbow effect, trim the tree in a downward spiral from top to bottom, from the end of each string to the end with the white connector. Connect the controller at the bottom of each string.



COLOR ORGAN

When power is applied, the LED strings will light solid violet, blue, green, and yellow, from top to bottom to confirm the proper connection. After two seconds, the color organ will start automatically.

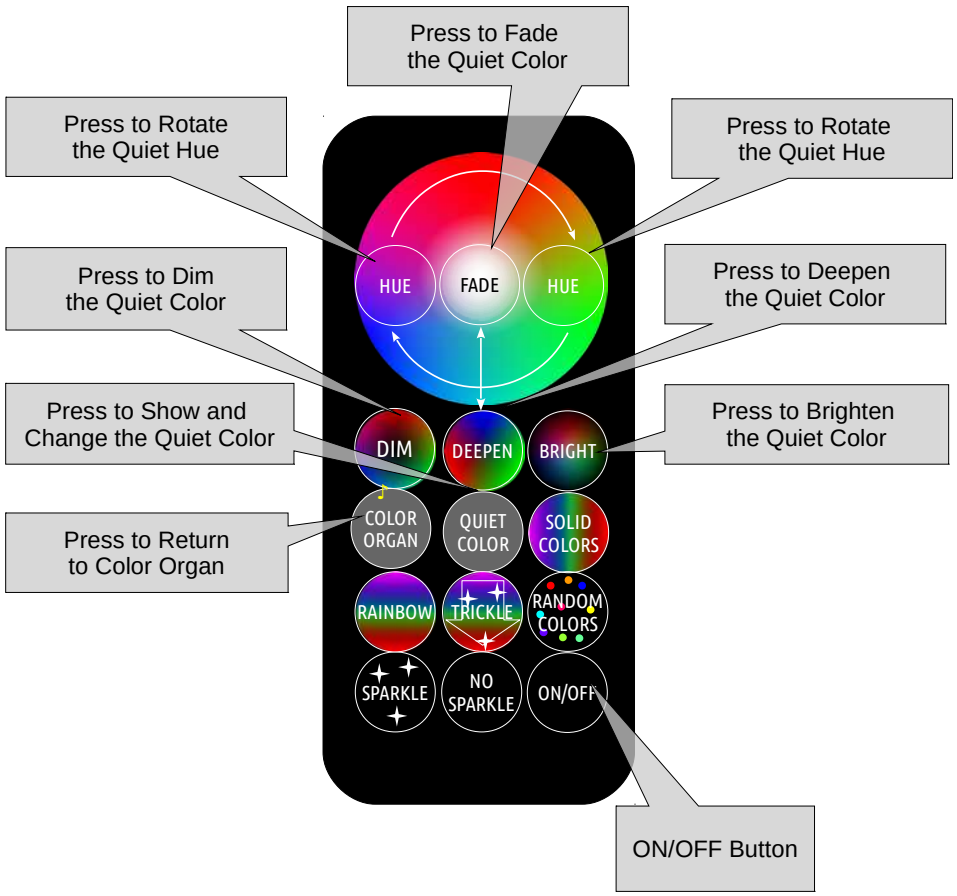
If there is an audio signal, the LEDs will begin to follow it instantly; otherwise, the LEDs will go out. If there are no other lights in the room or on the tree, this may be a bit stark, so you can opt for a "Quiet Color" which will take effect whenever the music stops.

The Quiet Color is adjustable by pressing the Quiet Color button. This stops color organ operation even with audio and shows the Quiet Color, initially blacked out. Press the **Bright** button to start with a dim white, which you can further **Brighten, Deepen** into a blue, then change that color by pressing a **Hue** button. Return to color organ by pressing the Color Organ button. Your new Quiet Color will remain in effect for as long as the controller is plugged into power.

Volume Setting: The color organ self-adjusts to the level of the input signal over a fairly wide range, but if your volume setting or input signal is too low, the colors will not reach full brightness. If your volume setting is too high, no damage occurs but only soft passages will show color and loud passages will turn on all colors at once, producing mostly pastels. Whether you have control of this depends on the type of input source you are using. Line and record outputs on a stereo are best because they deliver a constant level independent of your volume setting.

The color organ can be turned OFF and back ON with the **ON/OFF** button. When turned back ON, the color organ will resume as it was when turned OFF, including the Quiet Color as long as the unit hasn't been unplugged while OFF.

Color Organ Controls



SPECIAL EFFECTS

As an alternative to music input, the Remote can be used to choose virtually any uniform color of arbitrary hue, saturation and brightness or one of the animations described below.

A Solid Color can be selected by pressing the Solid Colors button. Pressing it a second time will rotate around the **hue circle** shown on the remote; pressing it again and again will slow the rotation until a blink signals that its as slow as it can go.

A Rainbow can be selected by pressing the Rainbow button. Pressing Rainbow a second time will rotate it around the **hue circle** shown on the remote, with the effect that it appears to slide along the strings (or trickle down a tree.) Pressing Rainbow again and again will slow the trickle until a blink signals that its as slow as it can go.

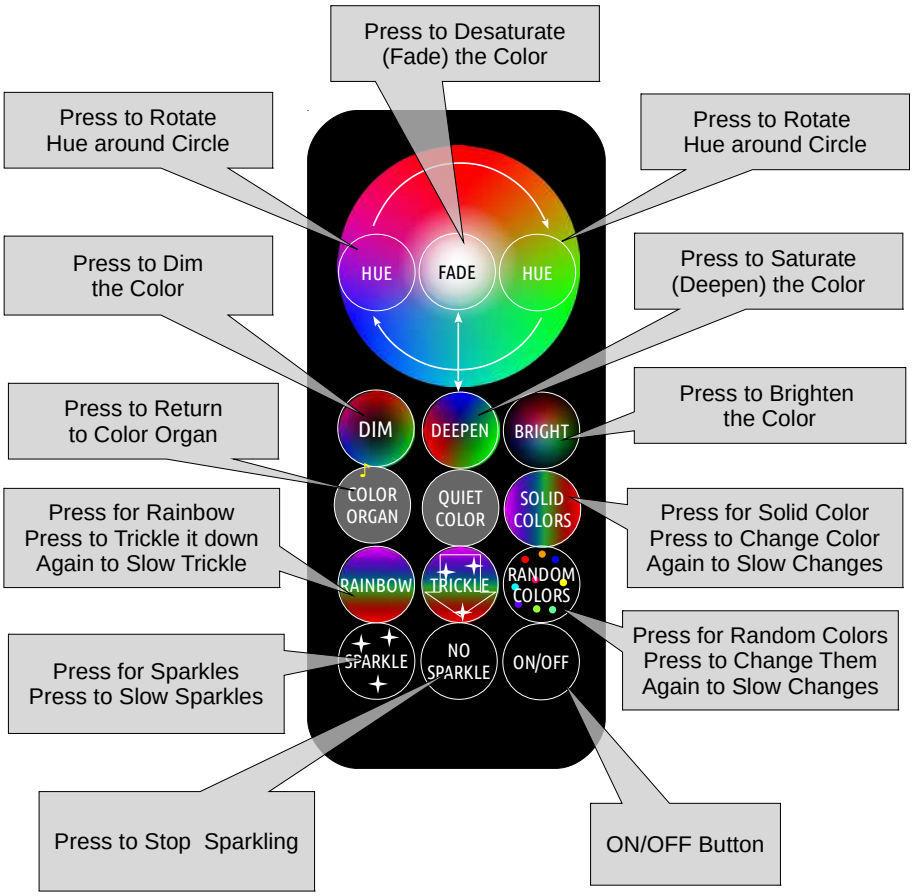
Random Colors can be selected by pressing the Random Colors button. Pressing it a second time will start changing colors randomly. Pressing Random Colors again and again will slow the changes until a blink signals that its as slow as it can go.

Sparkles can be added to any other effect by pressing the Sparkle button. Pressing it a second time will start changing colors randomly. Pressing Sparkle again and again will slow sparkling to the point you will barely see them. Sparkles can be turned OFF by pressing the **No Sparkle** Button.

Trickle Down Sparkle can be triggered with the Trickle Button. Pressing Trickle again and again will slow it down until a blink signals that its as slow as it can go.

The controller can be turned OFF and back ON with the **ON/OFF** button. When turned ON, the controller will resume the color organ or whatever special effect was running when it was turned OFF.

Special Effects Controls



TECHNICAL DETAILS

The LED Strings are Chinese made holiday strings based on the WS2811 digital RGB LED. Each "bulb" contains three LEDs, for Red, Green, and Blue, and a digital chip. A 12 volt DC poer passes down the string along with a digital signal from an Arduino DUE controller to address the chip in each bulb to set the brightness of its three LEDs. In color organ mode, all LEDs are addressed with the same data and follow music or speech on an audio input; in special effects modes, the LEDs are individually addressed to produce rainbow and random effects.

The Color-Selection Method for the special effects is a color "space" called Hue, Saturation, Brightness, or HSB. This is an option in many graphics programs and is used internally in the color television system. **Hue** is one of the "pure" colors around the edge of the color space diagram on the top of the remote.. it corresponds to the angular position around that circle, with read at the 12:00 position; blue at 8:00, and green at 4:00. White appears at the center of the space and **Saturation** is the radial distance from white, so halfway out towards blue is "light blue," etc. **Brightness** is the overall brightness of the display. In the old color TV system, Hue, Saturation, and Brightness were "Tint," "Color," and Brightness respectively.

The LEDs in the strings cannot produce all discernable colors, just as printer inks cannot. The range of colors in either case is called the "gamut."

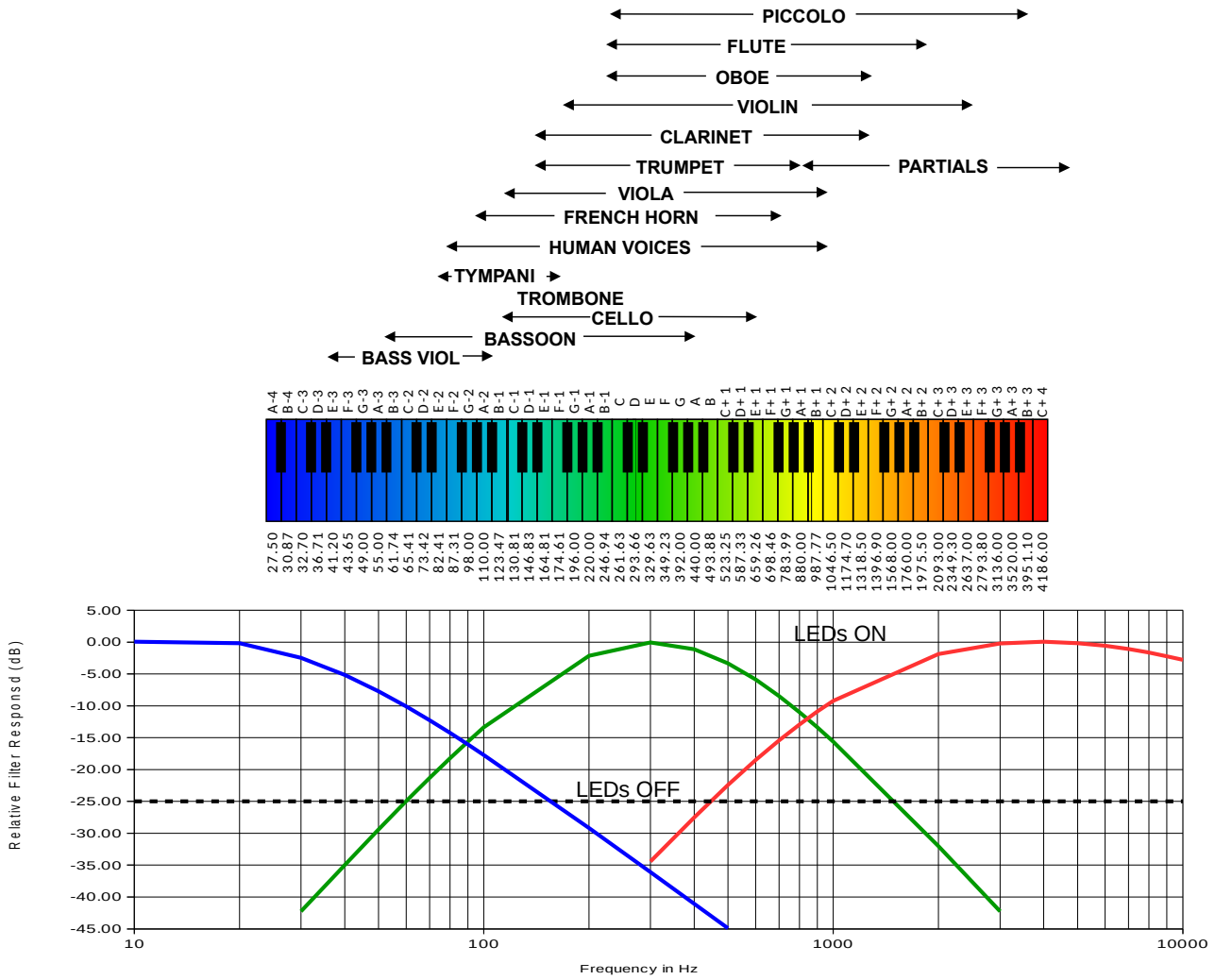
The Color Organ function animates music following the method patented to Frederic L. Way as US 3,018,683 and US 3,181,015 in 1962 and 1965. Way's first patent used filters and a motorized switch to control a resistive lamp dimmer; his later patent used a Silicon Controlled Rectifier, the predecessor to today's "Triac" wall dimmers, which was first commercialized in 1957. Way's patents were assigned to Mobilcolor, Inc, which leased the equipment to radio stations in Omaha and Indianapolis where it was used for holiday "Carol Tree" displays.

This digital implementation adds a fast Automatic Gain Control, digital filtering, full wave peak detection, time constants to approximate a Volume Unit (VU) meter response, and mapping of the signals to the LED intensity over a desirable dynamic range. Cascaded first order filters are used instead of Way's second order filters to make 10KHz sampling feasible on DUE. The filter crossovers are at 100Hz and 1000Hz instead of Way's 540Hz and 1800Hz, but these and all other "analog" parameters are named constants in the sketch so as to be easily tweaked.

WHAT YOU HEAR vs WHAT YOU SEE:

The following graphic compares the pitch range of the human voice and a number of musical instruments with the frequencies of Middle-C and its octaves and the frequency response of the color organ's three filters.

The chart doesn't necessarily imply that a given musical instrument will be seen entirely in one color. Most musical instruments produce not only a "fundamental" or musical pitch, but a series of multiples or near-multiples of that pitch called "harmonics" or "partials." The distribution of partials determines the difference between sounds, for example, a flute's sound, is mostly a single fundamental with relatively few partials, while the sound of a trumpet is mostly partials. For that reason, trumpets and other brass instruments will appear in the red, often bright red, even though the note they are playing is technically in the green range.



For a single-frequency tone from an electronic generator or a nearly musical pitch nearly free of higher frequency “harmonics” or “partials,” such as a pipe organ Tibia flute, additive color blending of red, green, and blue will produce secondary cyan and yellow only in the transitions where a single frequency partially clears two of the three filters. There is no intersection between red and blue, so magenta cannot be produced with a single tone. Magentas can certainly be generated by music, for example, where a bass line underlies a high pitched melody.

The ratio of the strongest to the weakest thing you can hear or see is called the dynamic range, and that of non-broadcast music is usually in excess of what WS2811 LEDs can display. This requires the color organ function to do some internal compression to make the device less “fussy” about levels. Broadcast stations do this to try to sound “louder” than competing stations and to make the entire progam audible over noise like that in a car. Compression has its limits, however, so if the input signal is too low, the colors will not reach full brightness. If too high, loud passages will turn on all colors at once, producing largely pastels.

The Controller is a variant of the Arduino, popular prototyping platform originally developed for students at the Interaction Design Institute Ivrea, Italy to create devices that interact with their environment using sensors and actuators. Common examples of such devices include simple robots, thermostats, and motion detectors. The “DUE” variant used here contains a relatively fast Atmel

SAM3X8E processor capable of performing the digital filter algorithms in real time. The program, called a “sketch,” reflecting its art-school origins, is coded in a dialect of ‘C. Two libraries of code are used for receiving and decoding the IR signals from the remote control and formatting the digital commands to the WS2811 strings; the digital filter and color calculations are unique.