HauntMaven.com - Wolfstone's Haunted Halloween Site

http://wolfstone.halloweenhost.com/ColorOrgans/clofix_DebuggingColorOrgans.html#OptocouplerBasedColorOrgans

Debugging Color Organs

Elsewhere on our web site, we discuss the theory and application of color organs. We also discuss the availability of commercial color organs and kits.

This page is dedicated to what can go wrong with a color organ.

CAUTION

Little battery-operated color organs that flash LEDs in time to the sound picked up from a microphone are relatively safe to work on. The worst you can do is destroy your project, of burn yourself on your soldering iron.

But any color organ that plugs into the wall deals with hazardous voltages. If you aren't prepared to know and follow high-voltage precautions, you shouldn't be poking around in a line-operated appliance!

Preliminary Examination

Before you start screwing around with the gadget, take a moment to look it over closely.

- Is it physically damaged? Cracked case or busted parts? Waterlogged?
- Is it plugged in and turned on?
- Does the pilot light come on?
- Is the fuse OK?
- Are the lamps plugged in to it?
- Have you tested the lamps to make sure they work?

For testing color organs, I have found it handy to get a set of small, identical incandescent lamps. Small night-lights from your local discount store would be fine. Plug them all in, power up the color organ, and see if some of the channels work and others do not.

You Need A Schematic

For any repair that is not utterly trivial, you will need a schematic diagram. If your gadget was built from an electronic kit, you should have the schematic, pictorial diagram, and maybe some trouble-shooting tips.

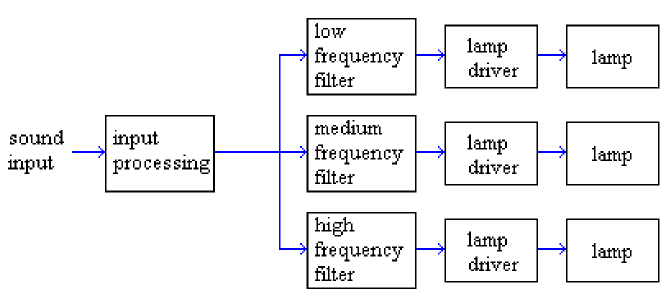
If you have thrown out the documentation, you might try contacting the kit manufacturer for replacement paperwork.

When all else fails, you can trace out the circuit yourself, reverse-engineering it.

General Theory Of Operation

A simple one-channel light organ has a very simple task: it listens to a source of sound, and controls a lamp, so that when the sound gets louder, the lamp gets brighter.

Fancier color organs have multiple channels, each of which is sensitive to a different sound frequency (pitch) range. The high note of an alto flute might light a red light, while the low-pitched thump of a bass drum might light a blue light.



General block diagram of a three-channel color organ.

Why Many Color Organs Are Poor

I've never had many problems with the color organs I have experimented with, but in writing this page I have seen many examples of poor design. Some parts of the designs simply won't work as the designer had obviously hoped they would.

How can color organs get away with not working properly? I believe that the reason for this is that color organs are simply not a demanding application, so defects are not readily noticed.

Consider a very high-end color organ with 12 channels, with a light for each channel lined up in a row. The color organ is running at a piano recital, part of which includes a smooth run from the lowest note of the keyboard to the top. As the notes run higher, the lights follow, and the crowd loves it. This is a demanding application. I'll bet this kind of thing is rare.

Consider a D.J. using a common three-channel color organ. Each channel drives a couple of PAR cans, shining on the dance floor. The music is loud and fast. So are the dancers. Do you think that anybody will really *notice* precisely how the lights correspond to the sounds? Do you think anybody will really *care*?

So, most of the time sloppy operation is good enough. It's cheaper and easier to design and build something sloppy. And if nobody ever notices a defect, they will never complain, and the defect will never be resolved.

Low Overall Sensitivity

If none of the channels in a color organ respond well, the problem is probably due to the way that the sound is brought into the color organ.

Color organs vary in how they get the sound input that drives them.

- Some use a microphone, which is quick and convenient to set up, but can pick up background noise.
- Some color organs are wired directly to the sound source, such as your stereo. This eliminates background noise, but brings up a new problem: you don't want a malfunctioning color organ feeding 110 VAC into your stereo and blowing it up.
    - Some circuits use transformers to isolate the stereo from the color organ.
    - Some color organs have a low-voltage section that interfaces directly with the stereo, a high-voltage section that controls the lights, and an interface in between.
    - The modern solution is to use an optocoupler (also known as an optoisolator).

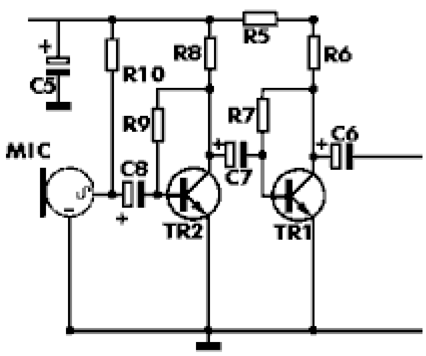
But before we go into the details, please make sure that:

- You have hooked up the color organ to the right type of audio source. If the unit is designed to run from speaker-level signals, it won't work when plugged into the "line" output.
- Have you tried turning up the volume?

Microphone-Input Color Organs

I have seen several variations on this theme, including:

- electret microphone (also called a "condenser" microphone)
- crystal microphone
- small loudspeaker, used as a dynamic microphone



This is the input side of Smart Kit Electronics SmartKit #1014D. It uses an electret microphone and a two-transistor amplifier.

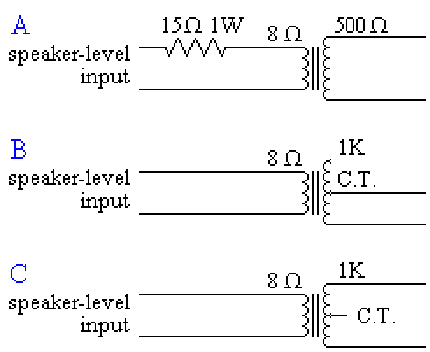
Note that a low voltage DC supply is required to run it.

The Graymark #G152 uses a crystal microphone for sound input. The CTI Kit #9935 allows use of a crystal microphone as one of its sound input options.

The Chaney Electronics #C6353 is an example of a color organ that uses a speaker as a dynamic microphone.

Transformer-Isolated Color Organs

Here are some typical transformer-isolated input stages:

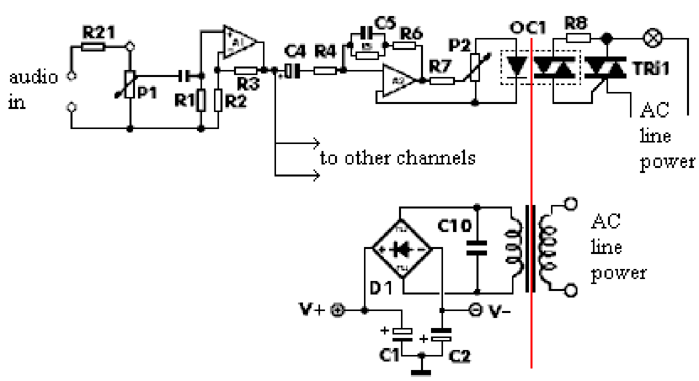


- "A" is Ramsey Electronics #ML-1. The resistor prevents the color organ from drawing excess current from the stereo. It's probably a good idea.
- "C" is similar to CtiKit #9936, except that their schematic does not show the center tap.

If your color organ uses a similar circuit and doesn't react well, here are some things to try:

- Reduce the value of the resistor in series with the 8-Ohm side of the transformer. [Type A]
- Replace the 8:500 transformer with a 8:1K transformer. [Type A]
- Use a different output tap on the transformer. If you move from the center tap to the 1K tap, you will double the signal coming in to the color organ. [Type B]
- Replace the 8:1K transformer with a 8:2K transformer. If you can't find one, try two 8:1K transformers (8-Ohm sides in parallel; 1K sides in series, aiding not bucking). [Type C]

Two-Section Color Organs



This is part of the Smart Kit Electronics SmartKit #1132D.

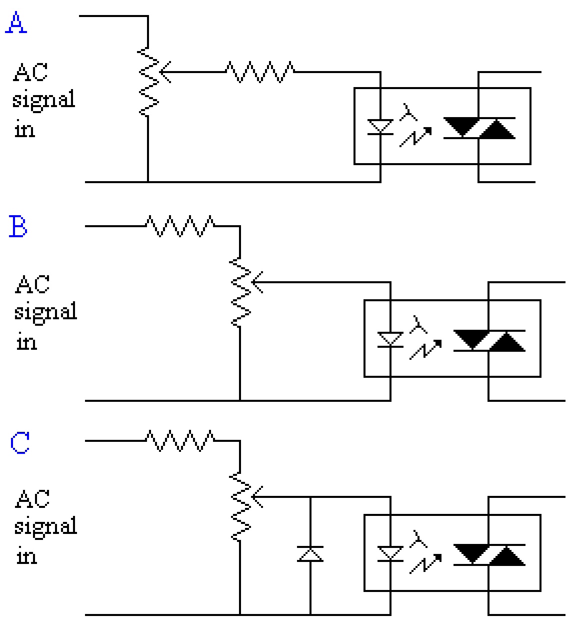
I moved some things around and drew a red line to highlight the fact that one section (on the left) operates at a low voltage, and is isolated from the section that operates at a high voltage (on the right).

In this type of design, there is no isolation between the electronics of your stereo and the electronics of the color organ. But since the *portion* of the color organ that listens to your stereo operates at a low voltage, the stereo should still be safe.

Optocoupler-Based Color Organs

The modern way of hooking a color organ to your stereo is to use an optocoupler (also known as an optoisolator). Notice that I didn't say that this is the best solution. Optocoupler-based designs are very safe, but have a reputation for being finicky.

Here are some typical optocoupler-based input stages:



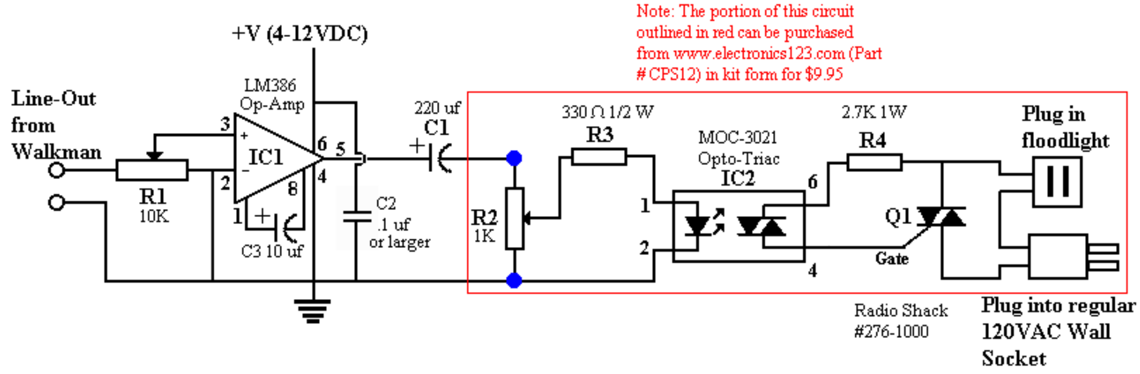
- "A" is DIY Electronics Kit 12.
- "B" is Smart Kit Electronics SmartKit #1006D.
- "C" is Velleman MK110. The extra diode protects the optocoupler from reverse voltage. It's a good idea.

In all cases, the potentiometer lets you adjust the sensitivity, while the fixed resistor protects against high voltage peaks in the signal.

- These units usually have polarity-sensitive audio input. If it fails to work for you, reverse the speaker-level inputs.
- The device requires speaker-level input.
  - It will not work with line-level audio.
  - Hook it up in *parallel* with your speakers.
- These units often have poor sensitivity, and requires loud sounds to drive them. You really have to crank up the amp.
  - It probably won't work with a Walkman-style sound source. There's just not enough volume there.
  - DIY Electronics Kit 12 specifies an input trigger voltage of 2.3 - 2.5V (min). The kit's trouble-shooting guide says "It needs 1.2V and a current of 5mA (approx). A small tape recorder or radio will need an amplifier stage to amplify the signal before supplying it to the audio input."
  - DATAKITS #80-120 specifies input voltage: 1.2 to 1.5 volt.
  - Velleman MK110 specifies an input signal of 2-60 Watts.
  - Smart Kit Electronics #1133 specifies input sensitivity of 2-60 Watts.
  - http://www.hauntedillinois.com says that Electronics123 #CPS12 requires that "input power level must be at least 2W".
- But don't crank the sound up too high, or you can destroy the optocoupler.

If you have tried one of these and have some tips or comments for users, please pass them along!

Because optocoupler-based color organs require a strong signal, they can't operate with low input signals like a microphone or line-level. You can remedy this situation by adding an amplifier. This diagram, from http://www.hauntedillinois.com, shows a simple amplifier that makes the color organ run from low input levels:



For details, please visit the nice folks at http://www.hauntedillinois.com.

Low Sensitivity On Some Channels

If some channels work fine, and some hardly flicker at all, you have two likely possibilities:

- Your sounds don't extend into the region that the channel is designed for.
- The channel's filter is listening to the wrong part of the frequency spectrum.

Your Sound Is Off

Most multichannel color organs are designed to respond to a wide range of music. So we're probably talking at least three octaves. More is better, and an ideal design would probably cover the range of human hearing. Three channel units are common, but color organs with more channels are certainly available.

Envision a nice three-channel color organ:

frequency range	light color	responds well to
high	red	alto flute

medium	yellow	trumpet
low	blue	bass drum

You're in the middle of a concert, and everything is going fine.

Then, there is a flute solo and all you see is red light for 10 minutes.

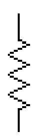
You have several choices on how to deal with this:

- Enjoy the red light. Sooner or later, you'll get 5 minutes of blue light when the bass drum takes over.
- Turn up the sensitivity of the other channels, so that the little bits of medium and low frequency sound that are there produce a visible response.
- Shift the frequency response of the other two channels (or perhaps all three), so that all the high-frequency band occupied by the flute is itself broken into smaller sub-bands, one per channel.

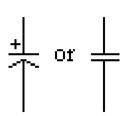
If you want to preserve the general-purpose nature of the color organ, you will probably want to leave it alone, or perhaps turn up the sensitivity on the lower channels.

But if the only purpose of the color organ is to serve on application, like simulating lightning, it's silly to spend money for color organ channels that respond to audio prequencies not present in a thundercrash. That would be a good time to alter the frequency responses of the channels.

General Theory Of Frequency Selection



This is the schematic symbol for a "resistor". It resists the flow of electricity (AC and DC), throwing away some of it as heat. For most resistors, *the amount of resistance does not depend on the frequency of an AC signal through it.*



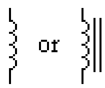
These are the schematic symbols for "capacitors". They acts like resistors (capacitive reactance) with a value depending on the frequency of the AC signal. *The higher the frequency, the lower the resistance.*

Capacitive reactance is given by the formula:

$$X_C = 1 / (2\pi f C)$$

where:

- X_C = capacitive reactance, measured in Ohms
- f = frequency of AC in Hertz
- C = capacitance in Farad



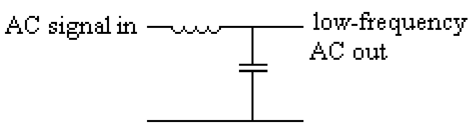
These are the schematic symbols for "inductors", They act like resistors with a value depending on the frequency of the AC signal. *The lower the frequency, the lower the resitance.*

Inductive reactance is given by the formula:

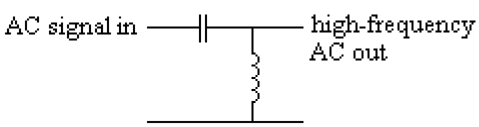
$$X_L = 2\pi f L$$

where:

- X_L = inductive reactance, measured in Ohms
- f = frequency of AC, in Hertz
- L = is the inductance, in henry

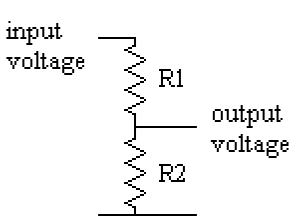


This is a simple L/C "lowpass" filter. Low frequencies encounter little resistance from the inductor and pass easily through. Any high frequencies that get through the inductor are shorted out by the capacitor.



This is a simple L/C "highpass" filter. High frequencies encounter little resistance from the capacitor and pass easily through. Any low frequencies that get through the capacitor and shorted to ground by the inductor.

If you prefer to think of it in a slightly different way, this is a voltage divider.



This voltage divider uses resistors.

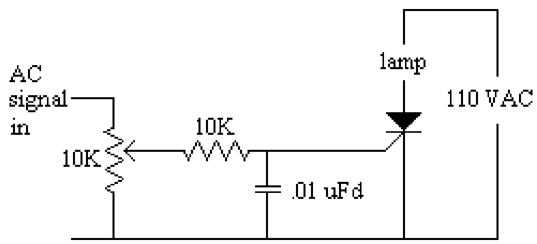
The output voltage (taken across R2) is R2 / (R1 + R2).

The L/C circuits are also voltage-dividers. Instead of using resistors, the effective resistance is provided by frequency-sensitive components.

Well, inductors cost a few cents more than resistors. I have yet to see a kit that uses them. Instead, kits tend to use R/C filters, where a voltage divider is composed of a resistor and a single frequency-sensitive component (a capacitor). The filter is not as precise and sharp, and that's probably just fine for the intended purpose.

For the sake of discussion, we will consider a color organ that responds to frequencies from 500 Hz to 2 kHz.

Changing The Low Frequency Channel



This is the low-frequency channel of the Ramsey Electronics #ML-1.

It is fairly typical for inexpensive color organs.

A microfarad (uFd) is 0.000,001 F, so the capacitor in the schematic is 0.000,000,01 F. Let's see how much of the signal gets through the voltage divider at several frequencies.

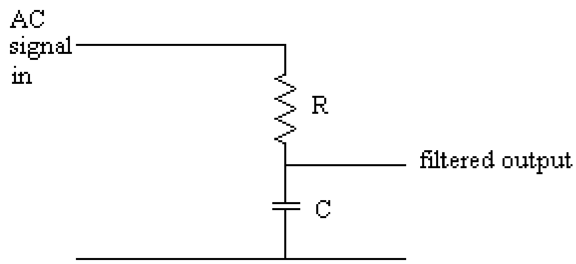
frequency	**capacitor value**	**capacitive reactance**	**fraction of signal passed**
500 Hz	.01 uFd	32000 Ohms	.76
1 kHz	.01 uFd	16000 Ohms	.61
1.5 kHz	.01 uFd	11000 Ohms	.51
2 kHz	.01 uFd	8000 Ohms	.44

What happens to the low end when we change the capacitor?

frequency	**capacitor value**	**capacitive reactance**	**fraction of signal passed**
500 Hz	.001 uFd	320000 Ohms	.97
500 Hz	.01 uFd	32000 Ohms	.76
500 Hz	.1 uFd	3200 Ohms	.24

By lowering the value of the capacitor, you can get a stronger signal out of the low channel.

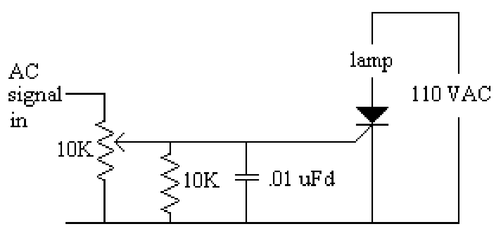
We put together a little JavaScript calculator that will let you play with these calculations.



We will use as a model this simple low-pass R/C filter.

Changing The Mid Frequency Channel

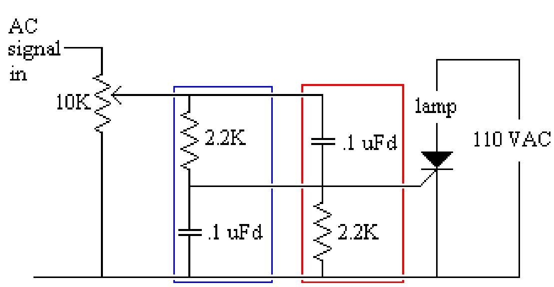
Usually, the middle channel is already good enough, and problems are only noted at the low and high ends. But for completeness, we'll mention the middle channel.



This is the mid-frequency channel of a design that will go nameless.

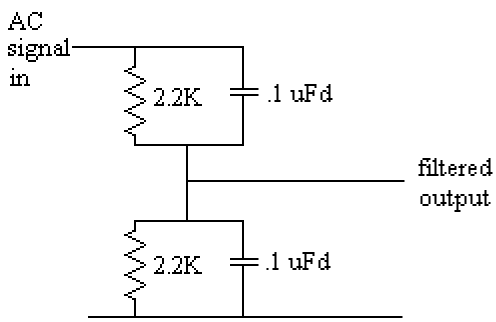
This design would probable be acceptable if it used an inductor instead of a resistor. The inductor would short out low frequencies, the capacitor would short out high frequencies, and we would be left with some stuff in the middle.

But the substitution of a resistor instead of an inductor ruins things. All we have here is a poor low-pass filter, with additional across-the board attenuation. Yuck!



This is the mid-frequency channel of another design that will go nameless.

I believe that the designer was trying to make a band-pass filter by routing the signal through first a low-pass filter (boxed in blue), and then a high-pass filter (boxed in red). Unfortunately, the ordering of the components in the schematic make little difference to where the electricity is going. Looking closer at the filter, and rearranging the components a little...

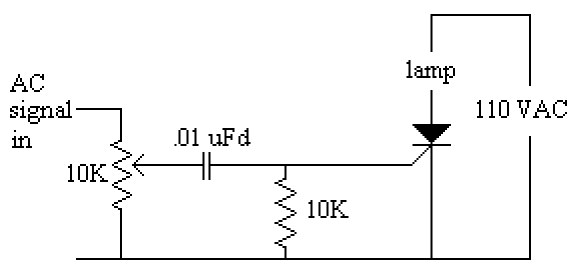


We really have a resistance and capacitive reactance in parallel. Ultimately, it provides a combined resistance with a value depending on the frequency of the signal.

The same R/C combo, with identical values, appears on the top and bottom. This forms a voltage divider that wastes half the signal coming in to it.

Since the top and the bottom have the same value (which varies depending on the frequency), the circuit will always divide the signal in half. The divider will just draw more current at high frequencies.

Changing The High Frequency Channel



This is the high-frequency channel of the Ramsey Electronics #ML-1.

It is fairly typical for inexpensive color organs.

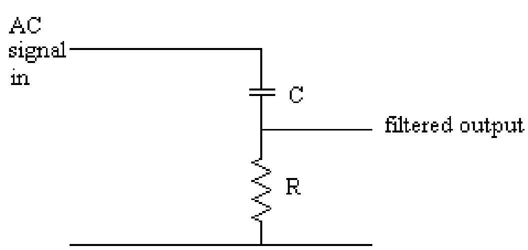
A microfarad (uFd) is 0.000,001 F, so the capacitor in the schematic is 0.000,000,01 F. Let's see how much of the signal gets through the voltage divider at several frequencies.

frequency	capacitor value	capacitive reactance	fraction of signal passed
500 Hz	.01 uFd	32000 Ohms	.24
1 kHz	.01 uFd	16000 Ohms	.39
1.5 kHz	.01 uFd	11000 Ohms	.49
2 kHz	.01 uFd	8000 Ohms	.56

What happens to the high end when we change the capacitor?

frequency	capacitor value	capacitive reactance	fraction of signal passed
2 kHz	.001 uFd	80000 Ohms	.11
2 kHz	.01 uFd	8000 Ohms	.56
2 kHz	.1 uFd	800 Ohms	.93

By raising the value of the capacitor, you can get a stronger signal out of the low channel.



We put together a little JavaScript calculator that will let you play with these calculations.

We will use this model of a simple high-pass R/C filter.

Output Driver Issues

The output circuit that drives a lamp generally works, or it doesn't. If one channel doesn't respond very well, but does respond some, it probably isn't a driver issue.

Things to check:

- A well-designed color organ has a fuse per channel. Make sure that all fuses are OK.
- Check the TRIAC, SCR, transistor, or whatever driver to make sure it works. If you don't have facilities to test the part, swap the part with one from a working channel.
- Note that the surest way to blow a channel in a color organ is to try to drive more watts than the unit is rated for. It might look really nice for a minute or two, then it just stops working.