Printed Electronic Display Laboratory!

One of the exciting capabilities that printed electronics can deliver to traditional print media is the incorporation of user-controlled electro-optic effects into graphic designs. With printed displays, the changes in color can be customized to be fast or slow depending upon the desired effect of the designer. After you have had the chance to interact with your CANVAS magazine cover, it can now be turned into a simple experiment or a “printed electronics display laboratory”, allowing you to create different effects from the same design!

Background

The printed display technology on the cover (NanoChromics™ technology from NTERA) features a coloring effect known as electrochromism. The display was created by printing a series of thin films using a specialized set of inks. A NanoChromics Display (NCD™) changes color when electric charge is applied to the printed films. The more charge you apply to the display, the more color change you will effect (until full contrast is achieved).

If you recall from your introductory physics classes, the movement of electric charge is actually an electric current. In the case of your CANVAS cover, the 1.5 Volt Blue Spark battery is the power source. It provides a small DC current (about 1 milli-amp) to the display when you dog-ear the corner. The NCD display actually works a bit like a capacitor, storing the charge from the battery as it colors. The faster you apply current, the faster the display will store the charge, and the faster it will change color. This means that connecting the NCD display to a power source with higher current capability would charge and color the display faster.

Because it is so thin and flexible, the Blue Spark battery is ideal for integrating printed electronic systems into these types of printed media. Contrast this to other electronic cover systems you may have seen powered by coin cells, or other conventional batteries! However, one of the trade-offs for this novel form factor is a smaller peak current. By comparison, a standard household 1.5 Volt AA battery can source about 50 milli-amps, or roughly 50 times the current of the battery on your cover. So, if you want to see your cover work faster let’s conduct some experiments!
Preparing Your CANVAS Cover for Experiments

Pull the cover from the magazine and turn it around. Carefully remove the battery from the display and scrape any residue to expose the electrical trace (silver ink). The system should look like this:

Once a battery is connected to the two ports highlighted above, placing a coin on switch 1 will color displays A and B, placing a coin on switch 2 colors displays C and D, and placing coins on switches 1, 2 and 3 will color all six displays.
The easiest way to connect a higher current source to the display is to use a household AA battery with a battery connector. If you don’t have a battery connector lying around, you can get one at RadioShack for just $0.99. Here is what it looks like:

You can look online for more information or to order one (http://www.radioshack.com/product/index.jsp?productId=2062247&CAWELAID=107594272). Or, you can even make one yourself! http://www.instructables.com/id/HOMEMADE-AA-BATTERY-CONNECTOR/

For the next steps, it may be easier to create broader connectors using traditional tape and conductive strips (aluminum foil works just fine) as illustrated below. Or, if you have steady hands, you can just proceed! Please make sure to cover the area 6 on shown to avoid creating a short by accident.
**Coloring Experiments**

Let's consider the following experiments for coloring the displays. Place the penny on switch 2 and hold it down (it may be easier to just tape it down. Connect the Blue Spark Technologies battery to the power contacts and observe the speed of coloring of displays C and D (As soon as the display reaches full contrast – no further color is observed - remove the battery to avoid overdriving the display). Wait for the displays to discharge. Now connect the AA battery to the power contacts. Observe how much quicker the coloring will take place (be sure to disconnect the battery quickly, or you can overdrive the display). You can repeat this same test using switches 1 and 3. You can also compare the impact of AAA vs. AA battery or even a new battery versus an old battery if you have some of those lying around.

Now let’s look at the impact of increased capacitance (or increased load for the electrical engineers) on the speed of coloring. Connect the AA battery to the power contacts. Press the penny on switch 1 and observe the speed at which displays A and B color. Wait for the display to discolor. Now place two pennies at the same time on switches 1 and 2 and notice that coloring of displays A and B takes longer than in the previous case. Wait for the displays to discolor. You may need a partner to help you and place pennies on each one of the three switches at the same time. You should notice that the coloring is slower.

**Bleaching Experiments**

Finally, let’s take a look at discoloring, or “bleaching” the display. As charge dissipates from the display, the color will fade. There are basically two ways to clear charges and bleach the display: natural charge leakage over time, or a user controlled forced bleach. The first mechanism is a result of natural charge loses in the display system – that is, the electric charge will dissipate over time as the electrons leak away from the coloring material (like a slow leak in your bathtub). The second mechanism is to forcibly create a short circuit between the two electrodes of the display. All you need is a paper clip or a large coin.

Take your battery and connect to the two power ports color the display, and apply the coin to switch #3 (being careful to remove the battery as soon as the display stops coloring (full contrast). Observe the time it takes for the displays E and F to discolor naturally. Apply the battery again to recolor the displays. Remove the battery, and now place the paper clip (or a large coin) between points 4 and 5. The images in displays E and F should discolor much faster than before.

**Conclusion**

We hope that you have had some fun experimenting with your CANVAS magazine cover! We also hope that you have learned something about the emerging technologies associated with printed electronics. There are some amazingly cool capabilities that are just coming onto the market, and most of these can be integrated into traditional print products today. The flexibility (pun intended!) of these technologies will allow designers an unlimited set of options for creating new, engaging and interactive products that incorporate different effects into traditional printed media. The future of print is bright and colorful!