DESIGNING AND MAKING A THERMOCHROMIC DISPLAY

WHAT YOU WILL LEARN

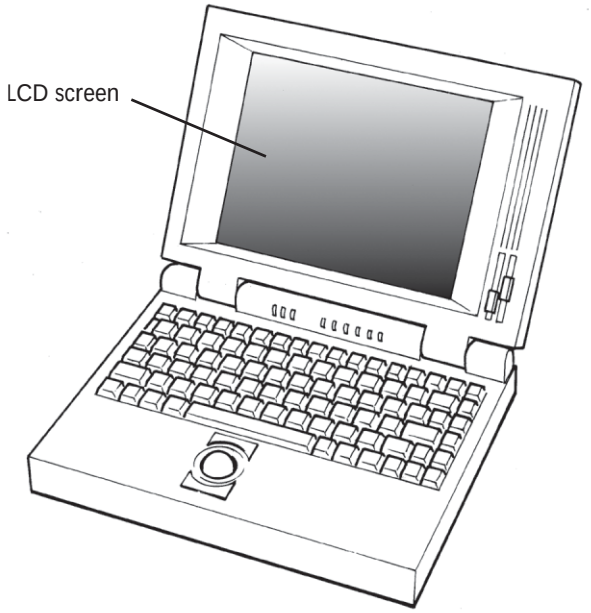
After completing this project, you should understand:

- The properties of thermochromic film.
- How thermochromic film can be used as a display.
- How to heat thermochromic film using resistance wire.
- How electronic control systems can be applied to heating thermochromic film.

After completing this project, you should be able to:

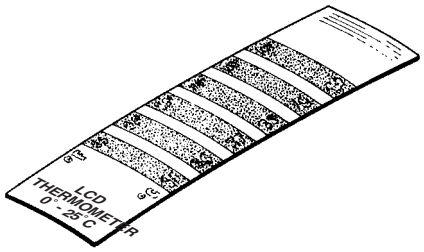
- Design and make a display screen using thermochromic film.
- Use resistance wire for low temperature heating.
- Apply at least one control system to control of heating thermochromic film.

Many products such as calculators and laptop computers show information using liquid crystal displays (LCDs). Liquid crystal is a very unusual material which responds to electrical signals.

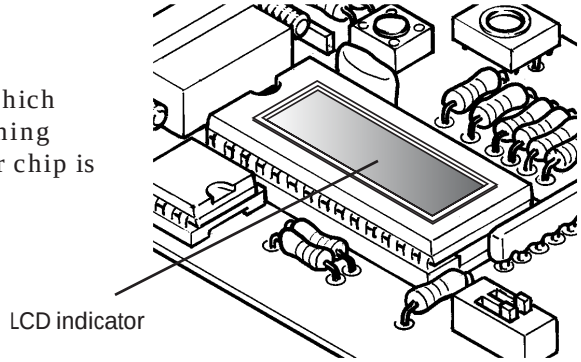


Thermochromic liquid crystal is a special form of the LCD material, but one which changes colour when heated. It is put into minute capsules by a process called microencapsulation and then made into an “ink” for printing onto plastic or paper. Thermochromic ink has a number of uses including:

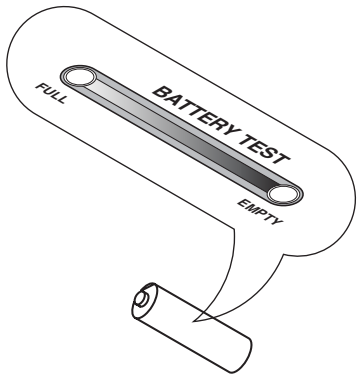
- thermometers which change colour along their length according to temperature,



- warning patches which show when something such as a computer chip is getting too hot,



- battery test panels.



In battery test panels thermochromic ink is printed on a material that heats up when current passes. If a battery is good, enough current passes through the material to heat up the ink and cause it to change colour.

It is now possible to obtain thin self-adhesive plastic film with a coating of thermochromic ink which changes colour at 27°C. This is called **thermocolour film** can be cut into any shape or to any size and can be used in many new products.

YOUR TASK

◀ DESIGN BRIEF

*Design and make an liquid crystal display based on thermocolour film and a resistance element. The display is for a purpose which you identify - e.g. a badge, warning device, advertising display. The display should be **controlled** by a switch or circuit.*

DESCRIBING YOUR TASK

◀ SPECIFICATION

First you need to describe in detail what the product will be like, what it will do and who will use it. This is called a design specification and will guide your design work and help you judge how well the outcome works.

Here are some questions to help you with your design specification:

- *Who will use the display ?*
- *What will it be used for ?*
- *What should it cost ?*
- *What materials and components will it use ?*
- *Will it require any special components for control ?*

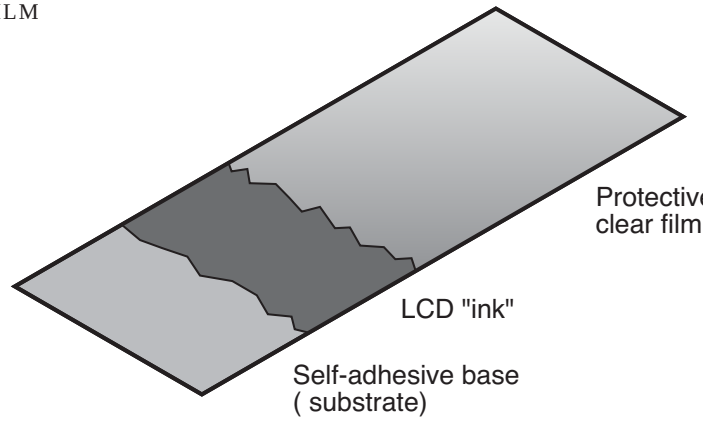
MATERIALS AND COMPONENTS PROVIDED

DESIGN CONSTRAINTS

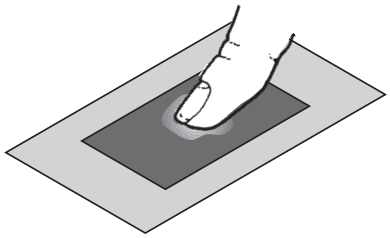
Before you get on with your design work, you need to know what materials and components are available. Your teacher will provide you with some of the items shown. Make a note of what is available and what you think you can supply.

ABOUT THERMOCOLOUR FILM

Thermocolour sheet consists of a plastic film (called a substrate) which has an adhesive on one side and thermochromic ink on the other. The ink coating is protected by a clear plastic film.

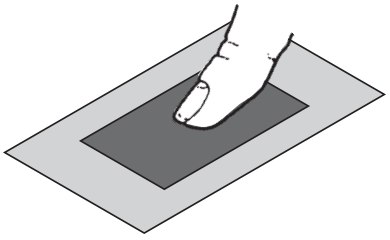


The film is normally black but changes colour to bright blue at 27°C. If you touch a piece of material for a few seconds the heat from your finger will cause it to change colour - unless your hands are cold ! You can make a “hand print” on a larger piece of the sheet.

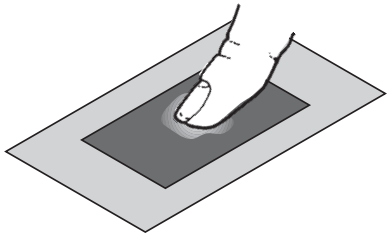


From a few simple experiments, you will see that:

- The film changes colour at 27°C. If your hand is cold or the sheet is stuck to a good thermal conductor such a metal, it will not change colour because the heat will be conducted away. The film should normally be bonded onto plastic or card which are both poor conductors of heat. If it has to be fixed to a metal base, an insulating layer (e.g. foamcore board) should be placed between the thermocolour film and the metal.

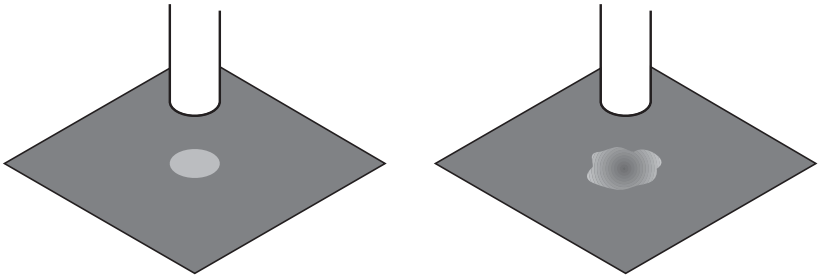


Good conductor
e.g. copper



Poor conductor
e.g. card or plastic

- Thermocolour sheet takes a little time to warm up but when the source of heat - e.g. your finger or a heated rod - is removed, the film stays warm for a short time. The blue colour then changes slowly to pale yellow and back to black. Also, if you watch the blue area, it continues to spread out slightly after the source of heat is taken away. This is because heat is conducted slightly through the film and affects the surrounding ink.

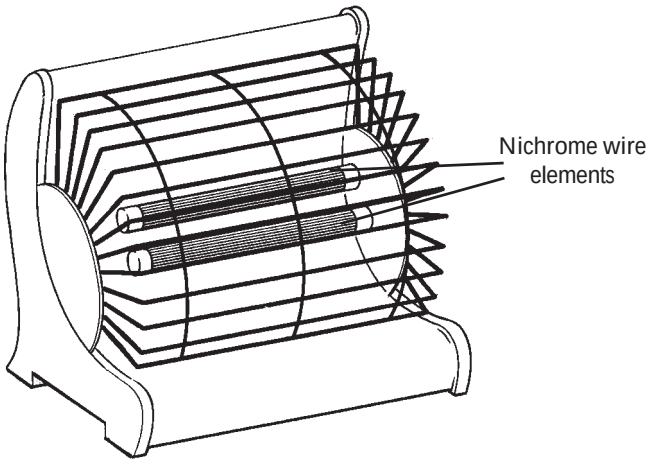


1. heated rod causes colour change

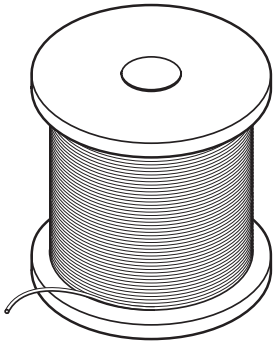
2. colour changes to yellow and spreads out

HEATING THERMOCOLOUR FILM WITH RESISTANCE WIRE

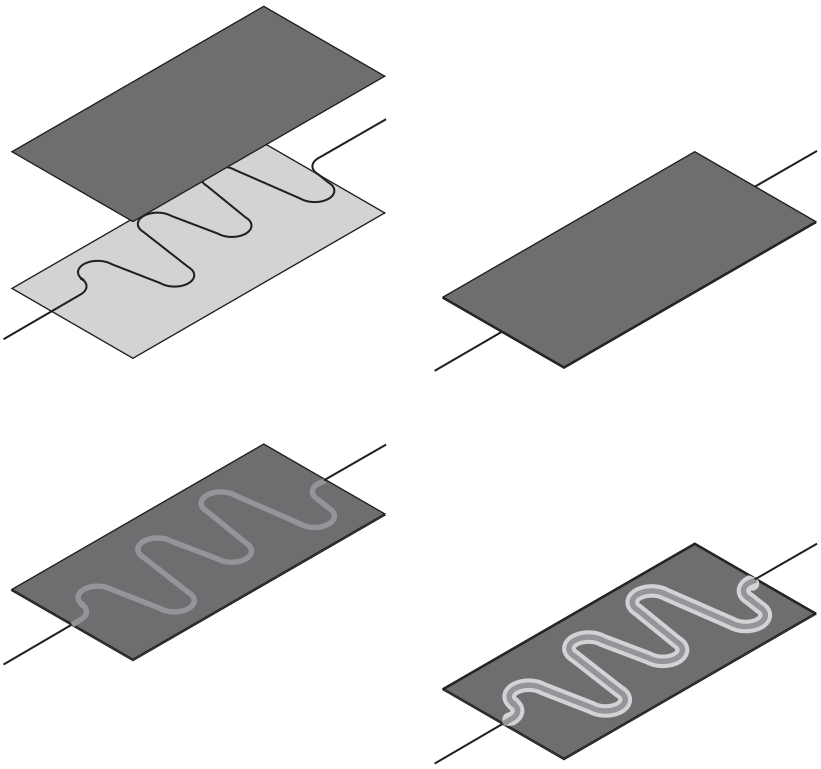
Many electric fires have an element of **nichrome** wire wound on a ceramic rod. Nichrome is an alloy (mixture) of Chromium and nickel. It has a high electrical resistance and gets hot when current passes.



The resistance of nichrome wire is determined by its diameter and length. The smaller the diameter and the longer the length, the higher the resistance. 0.3mm diameter nichrome wire has a resistance of approximately 1 ohm per 100 mm.



If you lay a length of nichrome wire on the sticky back of thermochromic sheet, it will stay in place until the protective paper backing sheet is replaced. When the wire is heated up using a battery, the film will change colour along the pathway of the wire.



Try an experiment using a 100mm length of 0.3mm diameter wire and a 3v battery (e.g. 2AA cells in a battery box). You can work out the current required using ohms law:

Current (I) = Voltage (V)/resistance (R)

UNDER NO CIRCUMSTANCES SHOULD YOU OVERHEAT THE WIRE USING A HIGHER VOLTAGE. IF IN DOUBT, ASK YOUR TEACHER.

You will see that the longer you heat the wire the more the blue area will spread out. It will continue to spread slightly after the battery has been disconnected.

SCIENCE OPPORTUNITY

Apply Ohms law to calculate current needed to heat wire.

WORKING OUT YOUR DESIGN

◀ DESIGN PROPOSALS

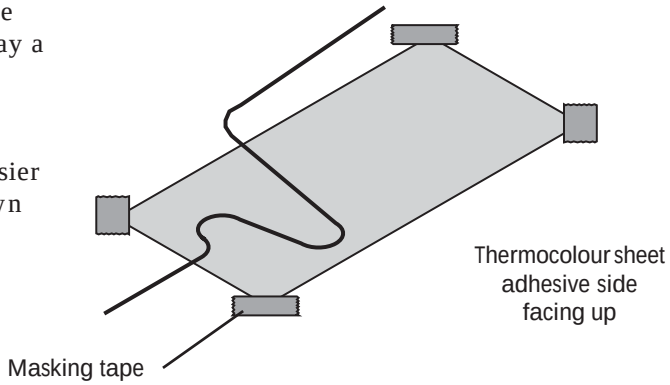
When you know what materials and components are available and once you have done some experiments, you need to think in more detail about your design:

- Set your ideas down on paper
- Experiment with your ideas
- Check your ideas against your specification
- Decide which is the best design
- Do a detailed drawing of the best design
- You need to end up with a working drawing which you or someone else can use to mark our, make and assemble the parts. It will be a good idea to draw out your design full size.

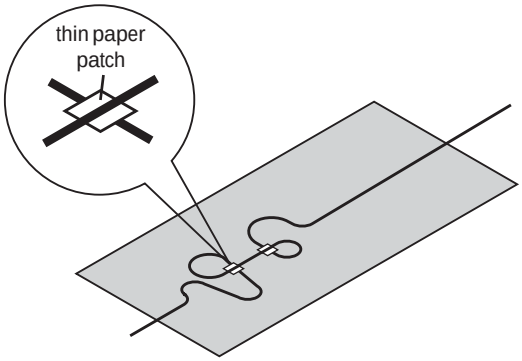
The following notes will give you some ideas about designing and making the display and controlling it. They do not give you the answers, though ! You must make the important decisions so that the display works as you intend.

THE THERMOCOLOUR DISPLAY

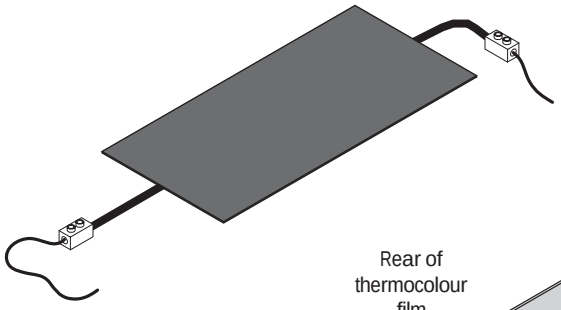
You might decide to use the thermocolour film to display a logo, sign or even a word. Shaping the thin wire and laying it onto the adhesive back of the film is made easier by taping the film face down with masking tape.

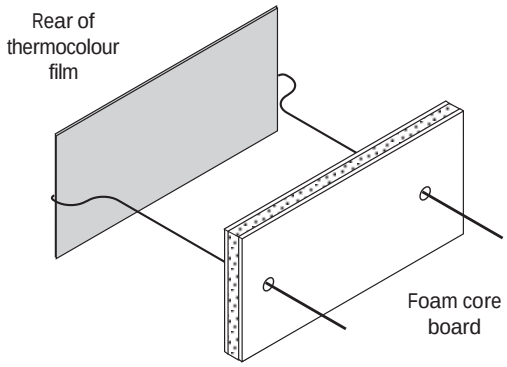


The nichrome wire should not cross over itself because there will be a short circuit - as the illustration shows. If the wire has to cross over in your design then use the smallest possible piece of paper as an insulator at the crossing.



The wire ends of the display should be covered, if possible, with heat-proof sleeving and then joined to connecting wires with terminal blocks.



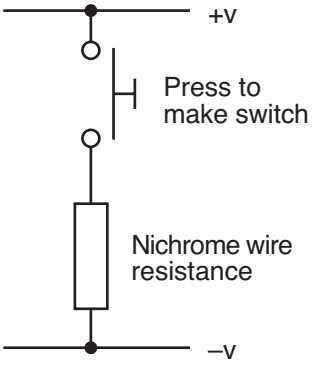


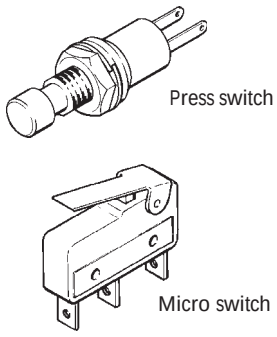
If the display is mounted, for example, on foamcore board or the surface of a case, the leads can be passed through holes so that they do not show.

CONTROLLING THE DISPLAY

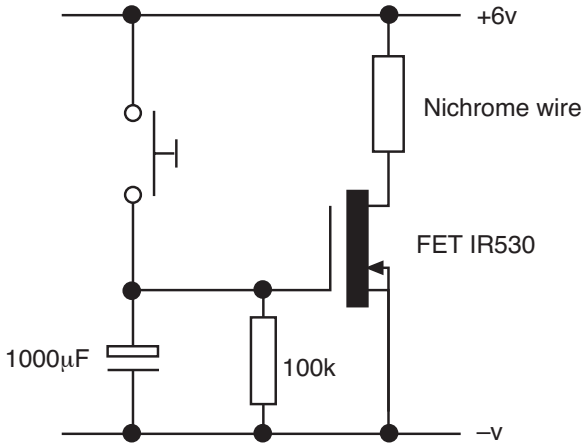
Ideally, the display should only be switched on for a short time so that the image does not spread out too much. Suitable control systems include:

1. Momentary-action switches.
The switches shown are "on" for only as long as they remain pressed.

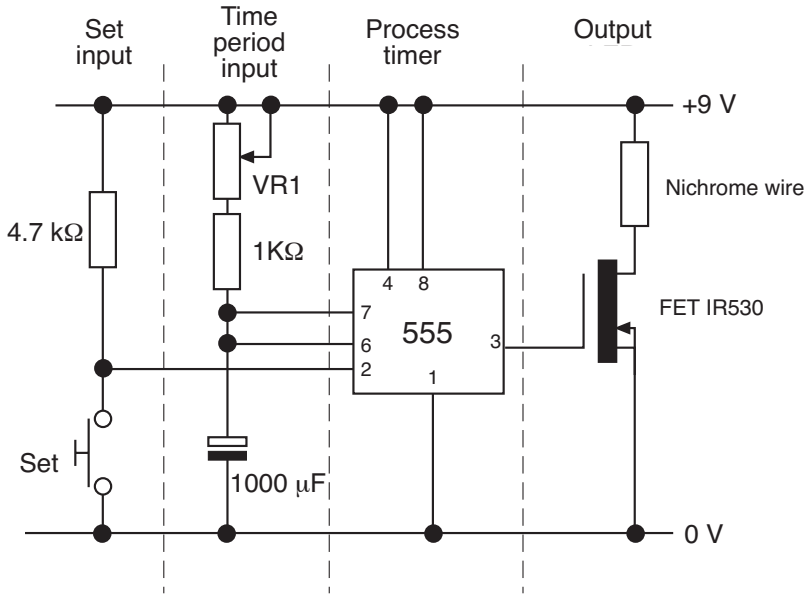




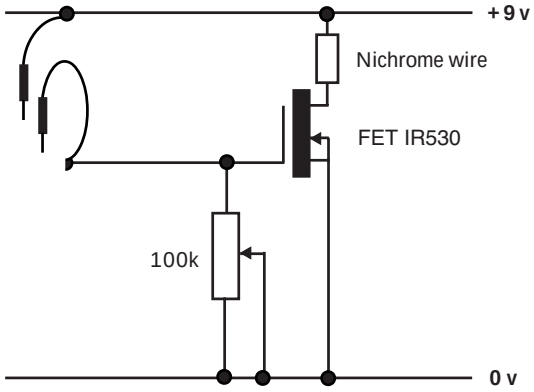
2. Delay-action control.
When the switch is closed briefly in the circuit shown, a capacitor charges up rapidly and keeps a transistor switched on for a several seconds. The delay period depends on the values of the capacitor and resistor. The higher the values, the longer the delay.



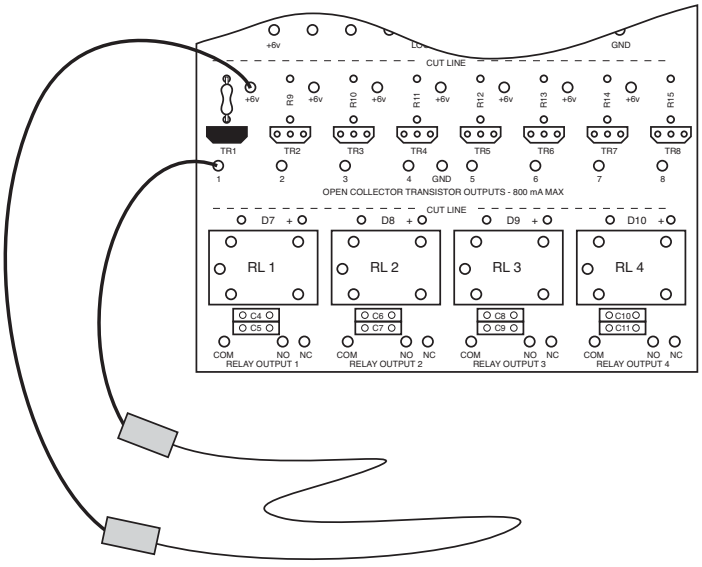
A delay circuit can also be made with a 555 timer chip as shown.



3. Sensor-control.
The sensor is part of a potential divider which turns on the transistor. The sensor shown consists of two probes that pass current when bridged by water.



4. Programmable display
The display can be programmed to turn on and off using the TEP Bit by Bit controller. The nichrome wire is connected to one of the transistor outputs. A smartcard controller can also be used which means the program can be stored on a removable card.



PUTTING IT ALL TOGETHER

◀ SYSTEM SYNTHESIS

Whether the thermocolour display is mounted on a case containing the control circuit or is separate, remember that it should **not** be in contact with a good conductor of heat. Ideally, it should be mounted on foamcore board. This can be done with Spraymount or double-sided tape.

Before fixing the display, make sure that the leads will be out of sight. This may prove to be the most difficult part in putting the complete display and controller together.

EVALUATING YOUR DISPLAY

To evaluate the success of your design, you must ask whether it meets your specification. You need to carry out some basic tests and then ask other people for their reactions. Here are some important points to look out for:

- *Does the display produce the image you want ?*
- *Does the display respond quickly enough when you switch on?*
- *Does the control system work as intended ?*
- *Do other people understand what the display means ?*
- *Is the display safe?*