# MINOS 2012

# SURFACE MOUNT TECHNOLOGY FOR SCHOOLS

Bernard Grabowski

## Introduction

Duncan Louttit and I have jointly run an after-school Micromouse club in High Wycombe for approaching 8 years.

Until this year we exclusively used through-the-hole technology as our schools, in common with many in the UK, already possessed soldering irons and the associated tools.

The mice the pupils made worked well enough in the end but took a long time to complete and often needed considerable rework and repairs due to dry joints and bridged tracks.

Hand soldering is a skill acquired over years of practice and in our experience very few pupils were good at it. Surface mount technology is perceived by many D&T teachers as difficult and expensive. If we were to convince schools that SMD is the way ahead we needed to take into account budgetary constraints and develop simple and reliable techniques.

## Pros and Cons

We had been looking at the feasibility of switching to surface mount technology for some time. We saw the pros and cons as:

| Pros | Cons |
|---|---|
| **Better quality control**<br>Minimal rework<br>Fewer damaged components<br><br>**Cheaper Mice**<br>Due to use of SMD components<br>usually cheaper than TTH<br><br>**Faster PCB construction**<br>So more time available for<br>programming and tuning<br><br>**Smaller, more versatile mice**<br>Due to smaller components<br>and more densely packed PCBs | **High initial setup costs**<br>Principally the reflow oven<br><br>**Rework more difficult**<br>Specialised tools may be required |

The reflow oven issue was a potential show-stopper. Schools are incredibly cost-conscious and expecting them to provide a dedicated reflow oven is very much wishful thinking. To make the change to surface mount technology happen we needed to find a cheap solution to the reflow oven problem and, of course, we needed to radically redesign the mice

## Development of a new schools' Micromouse

There are three schools' events at TechFest: wall-follower; line-follower and drag race. Duncan had long been convinced that it was feasible to have one mouse which could be competitive in all three events.

The problem was that the wall-follower needs to have its sensors in a different position to the other two events. Duplicating the sensors would have added at least £10 to the cost of each mouse so was not an option.

The breakthrough came when Duncan found a way to multiplex three LEDs pointing in different directions with a single Hamamatsu sensor. By mounting this array on a plug-in module, it could be positioned to the left of the mouse for wall-following and forward for line-following.

We now had a design which could be configured for all three events using one sensor and two motors to replace three separate mice using at least seven sensors and six motors. This gave us leeway to specify much better motor/gearboxes than previously used and still keep the cost per mouse below £25.

## Reflow Oven

Because Duncan possessed a reflow oven and was prepared to lug it to the school for several club meetings we went ahead. Nevertheless, I thought it worth pursuing a cheaper alternative as not all schools would have that option.

Having seen the toaster-oven demonstration by Garry a few years ago, I started searching for a suitable model on e-bay. My eye was caught by a second hand pizza oven which had been put up by someone half an hour's drive from me. It had a timer, a slide-out rack, heating elements above and below the rack and was rated at 1600W. The only thing it lacked was a built in thermometer. At £25 it was worth purchasing on spec and I fitted a digital meat thermometer to it for about £5.

I did some trials and established that, using lead-tin solder with both elements on and starting from cold, perfect results were obtained using a timer setting of three minutes.

The toaster oven is probably still the best solution to reflow on the cheap because domestic pizza ovens are more difficult to source.

## Results

I have brought some of the results of our first foray into surface mount to show you. These are the actual mice produced by our club members. They are all girls aged 12-13 and, with one exception, have no previous experience of electronics.

I turns out that they have a considerable aptitude for pick and placing components. We use an acetate mask to apply the solder paste and they work from detailed layout diagrams. They work at a rate of 100 components per hour. The main PCB was populated within 30 minutes. Some of them used their own eyebrow tweezers to handle the components! Their attention to detail and hand-to-eye coordination was such that almost no rework was needed.

In contrast, when they had to add the through-the hole components using hand-soldering, they worked comparatively slowly and we noticed a wide variation in soldering quality.

## Pupils' Experience

When we asked the girls to comment on the surface mount and through-the-hole techniques they had learnt, the general consensus was:

- TTH components are difficult to keep in place prior top soldering
- It is very easy to burn your fingers when using a soldering iron
- It was easy to position the SMD components.

Our observations very much backed this up. They found TTH work much more difficult and very easily wandered off task when engaged in hand soldering. This could lead to health and safety issues and required much closer supervision. The quality of the hand-soldering suffered as expected.

## Conclusion

There has already been a benefit in that for the first time we have mice fully built by Easter for the June competition. This allows ample time for programming and tuning and should avoid the need for major tweaking on the day.

Finally, far from being a difficult and expensive option for schools our experience shows that embracing surface mount technology can increase pupil motivation, improve quality of outcome and save money!