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Printed circuit board design in a school computer laboratory

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Abstract
Printed Circuit Boards replaced conventional wiring in most electronic equipment after World War II, reducing the size and weight of equipment while improving reliability and uniformity. PCBs are used in all kinds of electrical and electronic products because they can be mass-produced with greater circuit density and also enable easier trouble-shooting.

Computer Aided Design (CAD) is critical in teaching PCB layout design but it is a challenge for school and college instructors with limited budgets. After discussion of current trends in PCB design and development, as well as basic PCB design criteria, an affordable PCB design using an "educational" microcomputer is presented.

Keywords: PCB, design, layout, via "educational" microcomputers

The Printed Circuit Board (PCB) is a device in which the metallic conducting paths connecting circuit components are affixed to a flat, insulating base board.

The Development of PCB Design Technology and its Impacts
Of all the changes and advances that have taken place in the electronics industry in the twentieth century, the impact of the PCB must be one of the most significant. It is not so many years ago that the components used in electronic equipment were bulky and heavy and had to be mounted on a metal chassis. The introduction of and rapid expansion in the use of semiconductors and integrated circuits inevitably led to the increased use of the PCB. Today, from the cars we drive to the lamps, calculators, computers and entertainment equipment familiar to all, we take for granted the advances that PCBs have brought.

PCBs have greatly reduced the size and weight of the equipment while improving reliability and uniformity over the hand-soldered circuits formerly used. They can also be mass-produced efficiently. Furthermore, a board can have different printed circuitry on both sides or in many layers, allowing for increased compactness. Harris and Lall (1991:102) found "A common multilayer configuration consists of a five-layer circuit board ... but up to 42 layers have been used". Reis (1989:94-95) stated that PCBs offered many advantages such as "Less room for error, quicker assembly time, greater circuit density, ease in troubleshooting, less skill required, use of automatic assembly equipment, less prone to vibration problems, fewer gremlines". Because of these advantages, PCBs are now used in all kinds of electronic products. For the past decade, computers have been used to help design everything from space shuttles to kids' toys. A related benefit of a computer-aided design system is the ability to edit quickly, easily and accurately. Ginsberg (1991:195) indicated "There are three key reasons to use computer-aided design (CAD) tools to design printed circuit boards. First is increased productivity ... Second reason is increased design complexity ... Third reason is increased integration requirement". Clark (1985:16) pointed out the advantages of CAD artwork are "More accurate than a hand-made tape-up artwork; improved stability over the hand tape-up, and speed".

Trends in Printed Circuit Board Manufacture
Several methods and processes have been developed for manufacturing PCBs. Although...
most of them have not changed significantly over the years, some specific trends continue to exert major influences on the types of PCBs. These trends have led to the larger use of non-organic base substrate, such as aluminum and soft iron. Nakahara (1996:3.1) found:

1. Computers and portable telecommunications equipment require higher-frequency circuits, boards, and materials, and also use more functional components that generate considerable amounts of heat that need to be extracted.
2. Consumer products have incorporated digital products into their design, requiring more functionality at ever-lower total cost.
3. Products for all uses continue to get smaller and more functional, driving the total circuit package itself to become more dense, causing the PWBs (PCBs) to evolve to meet these needs.

Nakahara (1996:3.1-3.14) further classified the PCB according to its base material, graphic or discrete wiring, physical nature, conductor formation, the number of conductor layers, plated-through-holes (PTHs), and process.

Basic PCB Design Criteria

Baer (1973:184-185) suggested the following should be considered when designing PCB layouts: drilling or spotting guides, 90 degrees guidelines, just one critical dimension, land pattern around each hole at least 0.31" in width, the diameter of the copper pad to be at least 0.17" larger than the hole size, sharp corners on conductor paths to be avoided, spacing between conductors or land to be increased at least 0.01" over the required minimum. Figure 1 shows preferred and unacceptable design for PCB assembly.

The following are some minimum design standards:

1. All components will be oriented on the X or Y axis if possible.
2. Components will be mounted on only one side of the PC board.

![Preferred and unacceptable design for PCB assembly](image)
3. Components should be located so that any component can be removed from the board without removing any other part.
4. All boards must have at least two holes referenced to the layer.
5. Maintain minimum spacing for resistors (0.1"–0.25"+), capacitors (0.1"–0.5"+), ICs.
6. Components which dissipate more than 2W should not be mounted on a PC board and should be heat sunk to the chassis.
7. Allow 0.002"/ounce for etching tolerance.
8. Conductor path shall be at least 0.025" to the edge of the board and components shall be at least 0.05" from the edge of the board.
9. Conductor paths should be oriented to the XY coordinate system, if possible. Avoid sharp angles which can cause foil delamination. Always use the shortest routing.
10. Maintain uniform pattern around holes.

PCB Design Using an "Educational" Microcomputer

Equipment Needed:
Microcomputer 486 or better, Mouse, Keyboard, Laser Printer, AutoCAD, Microsoft Word.

Design Procedure:
1. Prepare a pencil layout with grid paper and pencil. Check carefully the layout with the original schematic diagram as shown in Figures 2 and 3 to make sure the layout is correct.
2. Create the PCB artwork. To create the PCB artwork, you can run the AutoCAD program with an IBM or IBM compatible microcomputer. After successfully getting into the AutoCAD program, you can create some "donuts" to be used. AutoCAD has a distinct advantage over manual drafting in electronic drawing. You can create a "library" of symbols once and then retrieve the symbol in your drawings. You can also use the "COPY" command to duplicate the "donuts" or traces so they will be the same size. The command "ZOOM" allows you to enlarge or reduce your drawings. Generally speaking, a 0.020" wide trace can carry up to 1.5 A of current and a 0.025" wide one can take up to 15 Amperes. Any trace less than 0.020" wide is likely to be eaten up by the etchant, therefore, "It is better to stay with traces at least 0.040" wide, just to be safe" (Reis, 1989:110). Figure 4 and Figure 5 are examples of the PCB artwork for the schematic diagram in Figure 2.

Conclusion
Printed circuits have been used in all kinds of electronic products for a long time. However, a PCB layout design is still new to many high school and college educators. The author found that although AutoCAD and Microsoft Word were not originally designed for PCB purpose, they do provide students with the opportunity to explore the power of using a microcomputer in PCB design and with usable results.
Figure 4 Master layout of the "Touch Switch" PCB artwork (1)

Figure 5 "Negative" layouts of the PCB artwork (2)

References


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