

The Fabrication of Pc Boards at Caltech

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1. The Fabrication of PC Boards at Caltech

This describes the procedure used in the summer of 1982 to fabricate PC boards for the NNCP/Homogeneous Machine project. The intent of this document is to describe the procedure in sufficient detail to allow another person to repeat the procedure.

An outline of the procedure is as follows: the Caltech wire-wrap software was used to create and verify a wirelist of the processor. Burroughs processed the wirelist and a mechanical specification of the board and made a set of masks. Multech corporation fabricated pc boards from the masks.

2. Caltech Software

The software at Caltech used for the documentation and prototyping of the NNCP boards was the CHIX/DIFF system created by Erik DeBenedictis. This system is described briefly in the document "CHIX Board Design System, User's Manual". The only persons known to have used this system successfully are Erik DeBenedictis, Jeffery Cavallero, Bill Athas, and Dan Whelan.

3. Burroughs Facilities

The relevant Burroughs facility is at Westlake village and the contact there is Ron Szabo (706-5144). The layout service was setup partially as a favor to Chuck Seitz. They indicated interest in repeating the service in the future.

Burroughs was supplied with a ANSI-ASCII magnetic tape containing a wirelist (to be described later), a plot showing the recommended placement of chips, a list describing the carrier type for each chip (14/16 pin dip, etc.), and a mechanical specification of the board (the IEEE multibus specification). Burroughs returned a set of 7 masks for a four layer pc board.

The format of the wirelist is as follows:

Signal Name	Pin
-----	---
F00	U17-35
RESET	U18-3
F00	U11-31
↑	↑
	ideally put in column 15, but no big deal if not...
9 chars max	

(Incidentally, this means that all signals have to have distinct names.) The ideal tape format is 1600 bpi phase encoded, 80 rec/block, no headers (standard data tape), and ascii is OK.

Our experience was as follows: The charge for the service was \$2000. We initially specified the placement of an entire row of chips incorrectly (backwards). Burroughs ran their router and came up with about 30 (automatically) unroutable wires. They manually routed these wires. When the misplacement was discovered, Burroughs was instructed to mirror the row of chips and try again. An extra charge of \$1500 was required because they had to do all the work over again. Burroughs did not mirror the two rows of chips, but instead did something else, and the problem got worse. DeBenedictis went to Westlake and instructed them as to the meaning of the instruction "mirror the row of chips" and they tried again. Burroughs again failed to mirror the rows of chips, but did something close enough that the result was acceptable.

Following the fabrication of the pc boards, it was discovered that Burroughs made another mistake: they put a 14 pin chip in a 16 pin socket, adding two unconnected pins as pins 15 and 16. The problem was in a human translation step.

Experience gained from the process was as follows: The person most familiar with the board must deal with Burroughs directly. That person should discuss the layout with Burroughs before they run and router and examine the failed-wire plot immediately after they run the router. It is strongly recommended that the wirelist be exactly correct the first time, because they cannot follow directions. If changes have to be made, simply send an entirely new wirelist. Also, check any steps implemented by humans: connector polarity, carrier size, etc.

4. Board Fabrication

Boards were fabricated by Multech (Multilayer Technology) in Santa Ana. Address is 2601 Oak Street, Santa Ana, CA 92707, (714) 754-6618. The contact there (and owner) is George Schreyer.

Multech is strongly recommended for future work. DeBenedictis contacted about 5 other outfits about making pc boards and none of them appeared interested in the business. We had the boards back from Multech while some of the places were still giving us quotes. Multech offered us three services: (1) \$75 per board, 80 boards, delivery in 4 weeks, (2) \$200 per board, 10 boards, delivery in 1.5 weeks, (3) \$1000 per board, 2 boards, 2 days.

Other contacts are (1) Steve Mozzer, Colbuk, 9232 Independence Ave., Chatsworth CA, 91311, (213) 341-4000, (2) Kathy Brown, National Technology Inc. (NTI), 1801 Newport Circle, Santa Ana, CA, 92705, (714) 546-6186, (3) Dave Hyde, ASI Inc., 88 N. Sepulveda, El Segundo, (213) 615-0204.

The package supplied by Burroughs was sufficient for a pc fabricator to work from directly (this included one page of specifications written out by Szabo).