

16 CHANNEL DIGITAL OUTPUT

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Here, we present the design of a 16 channel digital output for use with the bus system described at the authors' website:
george.ph.utexas.edu/~control

The basic features are as follows:

- Each channel is a single bit of output of a 16-bit device
- Addressable on a simple bus system.
- Each channel has line drive capacity to drive $50\ \Omega$ loads
- Convenient setup for laboratory electronics with BNC outputs

The circuit is relatively simple to understand from the schematic and is competitive with professional output boards such as those produced by National Instruments. This design is the digital compliment to the analog (DAC) device also described at the authors' website. The cost per board is roughly \$65 (\$40 for the board, \$5 for the ICs, transistors, and passives, \$20 for the BNC receptacles).

The Printed Circuit Board:

The PCB is a four layer board with signal lines on the top and the bottom. The second to the top layer is the location of the ground plane the third from the top is the power plane (+5 V). All ICs are located on the top as well power connector and ribbon cable connector. The vertical BNC receptacles are located on the bottom, making the board simple to front panel mount. The PCB was designed using the free software from PCB123, this company produced our circuit boards. For the design presented here, the PCB cost was about \$400 for 10 boards including silk layer charges. The software and information is available at the web site www.pcb123.com. The design of the board is shown in the printout pages near the end of this document and the design file is available at the author's website.

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Circuit Theory:

This circuit is simple to understand. The input consists of a 50 pin input header for a 50 conductor ribbon cable. The signals are spaced with ground lines between them giving 25 digital signals. The first 16 are the data bit lines, the next 8 are the address bus lines, and the final line is the strobe bit. The logic circuit works as follows. The strobe signal enters the comparator and is sent out if the local address matches. In this case, the strobe passes the comparator to command the latches to accept and hold the new 16 bits of data. Note that, for the DIP switches, the ON position indicates a LOW and the OFF position indicates a HIGH as far as the board address is concerned. The function of the latch is to have memory. The each latch holds old data in a buffer until it is commanded by the comparator's strobe to accept new data. Here, the new data is held until the next command to this board. All 16 digital outputs may be updated each clock cycle. The transistor line driver circuit is also a standard $50\ \Omega$ cable driver²

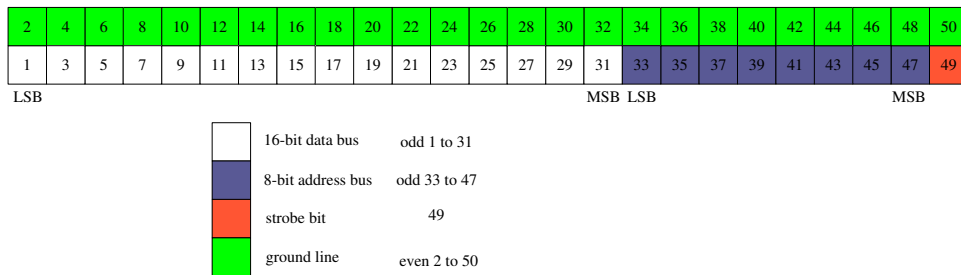


Figure 1: Pin configuration for 50-pin connector.

²see Figure 9.42 pg. 612 *The Art of Electronics 2nd Ed.* Horowitz and Hill. Cambridge Univ. Press 1989.

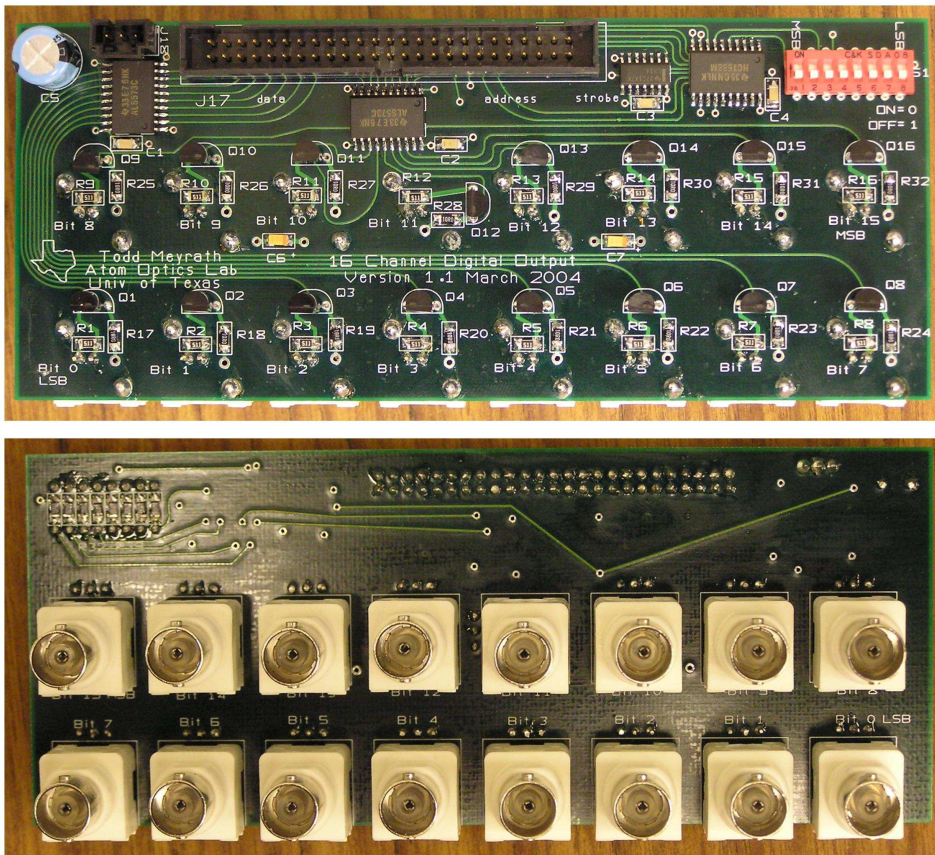


Figure 2: A completed board, both sides.

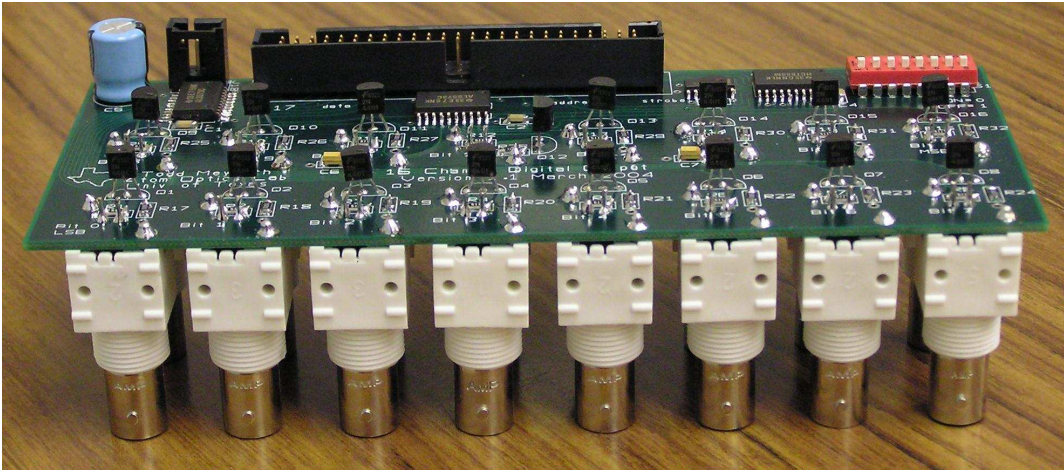


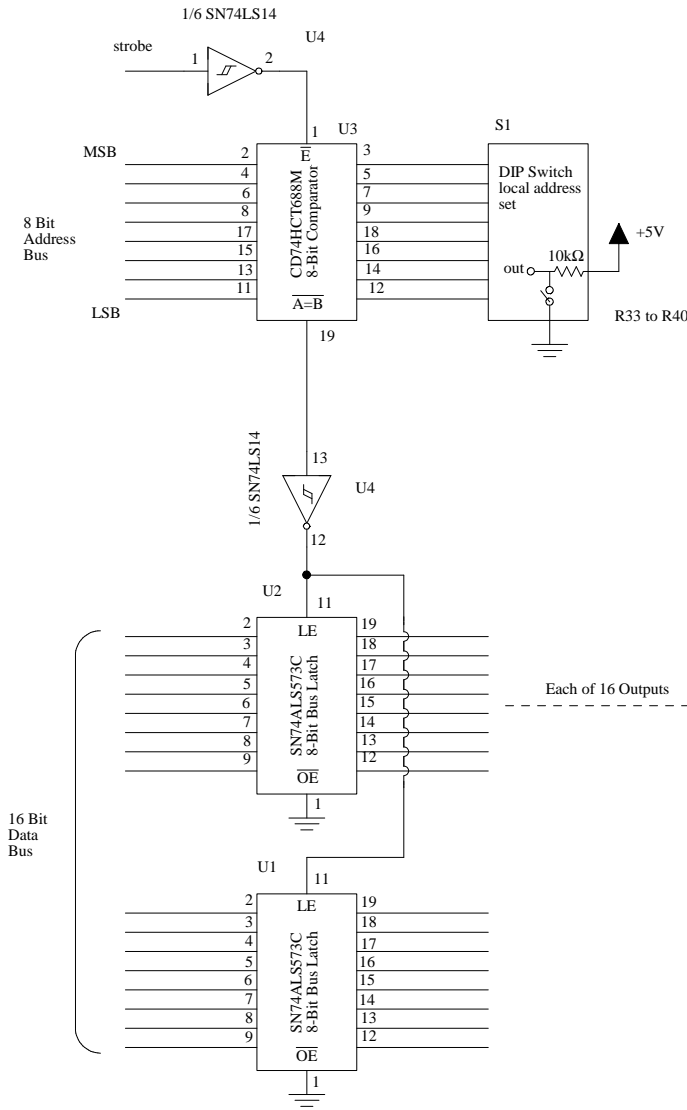
Figure 3: A completed board, a different view.

| Parts | | | |
|---|-----------|------------------|---|
| Qu. | Label | Part # | Manufacturer/Description |
| 4 | C1-C4 | 140-CC502B104K | Xicon / 100 nF cap, 1206 chip pkg. |
| 1 | C5 | | 470 μ F electrolytic capacitor 25 V |
| 2 | C6, C7 | T491A106M016AS | Kermet / 10 μ F solid tantalum surface mnt. |
| 2 | U1, U2 | SN74ALS573C | Texas Inst. / 8-Bit Latch, 20-SOIC wide pkg. |
| 1 | U3 | CD74HCT688M | Texas Inst. / 8-Bit Mag. Comp., 20-SOIC wide pkg. |
| 1 | U4 | SN74LS14D | Texas Inst. / Hex schmitt-trigger inverters, 14-SOIC pkg. |
| 16 | Q1 to Q16 | 2N4401 | Fairchild Semi / NPN transistor, TO-92 pkg. |
| 16 | R1-R16 | CRCW1206510RFKTA | Vishay/Dale / 510 Ω 1260 pkg resistor. |
| 16 | R17-R32 | CRCW120610R0FKTA | Vishay/Dale / 10 Ω 1260 pkg resistor. |
| 8 | R33-R40 | CRCW120610K0FKTA | Vishay/Dale / 10 k Ω 1260 pkg resistor. |
| 16 | J1 to J16 | 227222-1 | AMP-Tyco Elec. / Vertical PCB mnt BNC receptacle. |
| 1 | J17 | 1-103308-0 | AMP, Tyco / 50 pos. header. |
| 1 | J18 | 70543-0002 | Molex / 3 pin vertical header power conn. |
| 1 | | 50-57-9403 | Molex / 3 pin mate housing. |
| 1 | | 16-02-0102 | Molex / female crimp pins. |
| 1 | S1 | SDA08H1KD | ITT Ind. / 8 pos top slide DIP switch, 16-DIP pkg. |
| Quantity is per board, label is on the PCB, part # is manufacturer number. Most parts obtained from <i>www.mouser.com</i> , <i>www.digikey.com</i> , or <i>www.alliedelec.com</i> . | | | |

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Additional Connections:

