Chapter 17 from User's Manual V3.0

Classic 24-Bit Digital I/O Cards (DIN and DOUT)

In this chapter I'll cover the Classic 24-bit I/O cards (DIN and DOUT) along with the 24-bit test card (DOTEST). These cards were introduced with the release of the **Build Your Own Universal Computer Interface – Second Edition** book. Each Digital Input (DIN) card reads 24 input lines and each Digital Output (DOUT) card controls 24 outputs. There are a large number of these cards in existence and they work just fine with IBEC and USIC nodes and with SUSIC nodes configured with NDP$ = "N" i.e. no special features. Here's a summary of what works with which I/O cards.

- The IBEC works with any combination of 24- and 32-bit I/O cards (CIN24, COUT24, DIN, DOUT, DIN32 and DOUT32).

- The USIC works with any combination of the 24-bit I/O cards (CIN24, COUT24, DIN and DOUT) but will not work with either of the 32-bit cards (DIN32 and DOUT32).

- The SUSIC can be used with nodes configured with any combination of 24-bit I/O cards (CIN24, COUT24, DIN and DOUT) or it can be used with nodes configured with any combination of 32-bit I/O cards (DIN32 and DOUT32). However, you cannot mix 24-bit and 32-bit I/O cards within the same SUSIC node.

The major reason for a user acquiring additional DIN and DOUT cards is to expand an existing node containing 24-bit I/O cards. Another advantage of the DOUT card, over the newer 32-bit DOUT32 card, is the ability to substitute higher-current transistors for driving loads up to 60Vdc and 1A. Also, the DOUT card includes open-collector buffer ICs enabling the card to source outputs greater than the +5Vdc limitation inherent with the newer 32-bit design. In addition, the ability to select either inverting or non-inverting buffers makes the inclusion of the XOR software function irrelevant.

Ready-to-assemble DIN, DOUT and DOTEST cards are available from JLC Enterprises. Or if you prefer obtaining your boards as complete kits or fully assembled-and-tested, they are available from EASEE Interfaces. See Appendix A for details.

ADDRESS DECODING – USIC BASED NODES

Card address decoding for USIC-based nodes is identical to SUSIC-based decoding covered in the Chapter 11 section ***Address Decoding – SUSIC Based Nodes*** with the exception that the fourth port, port D, is not present and thus not decoded. With CIN24 and COUT24 cards (covered in Appendix F), the port D equivalent decode is used to access the 8255 IC's control byte. With the DIN and DOUT cards, the port D decode is simply ignored.

Because both USIC- and SUSIC-based nodes, as well as the IBEC-based parallel node, are capable of handling 64 I/O cards, every I/O card (CIN24, COUT24, DIN, DOUT, DIN32 and DOUT3) makes use of the same 6-segment DIP switch to set the I/O card address. Fundamentally, 6-segments can set 2 raised to power 6 or 64 different card address (0 through 63) as spelled out in Fig. 2-17.

DIGITAL 24-BIT OUTPUT CARD SCHEMATIC (DOUT)

Fig. 17-1 is the schematic for the general-purpose digital output card (DOUT). Every DOUT card is interchangeable with every other DOUT card. DIP switch SW1 is used to set each card's unique address. To simplify our understanding of the card, the schematic is divided into five functional areas: card address decode, port select decode, data out buffers, port data latches, and output line drivers.

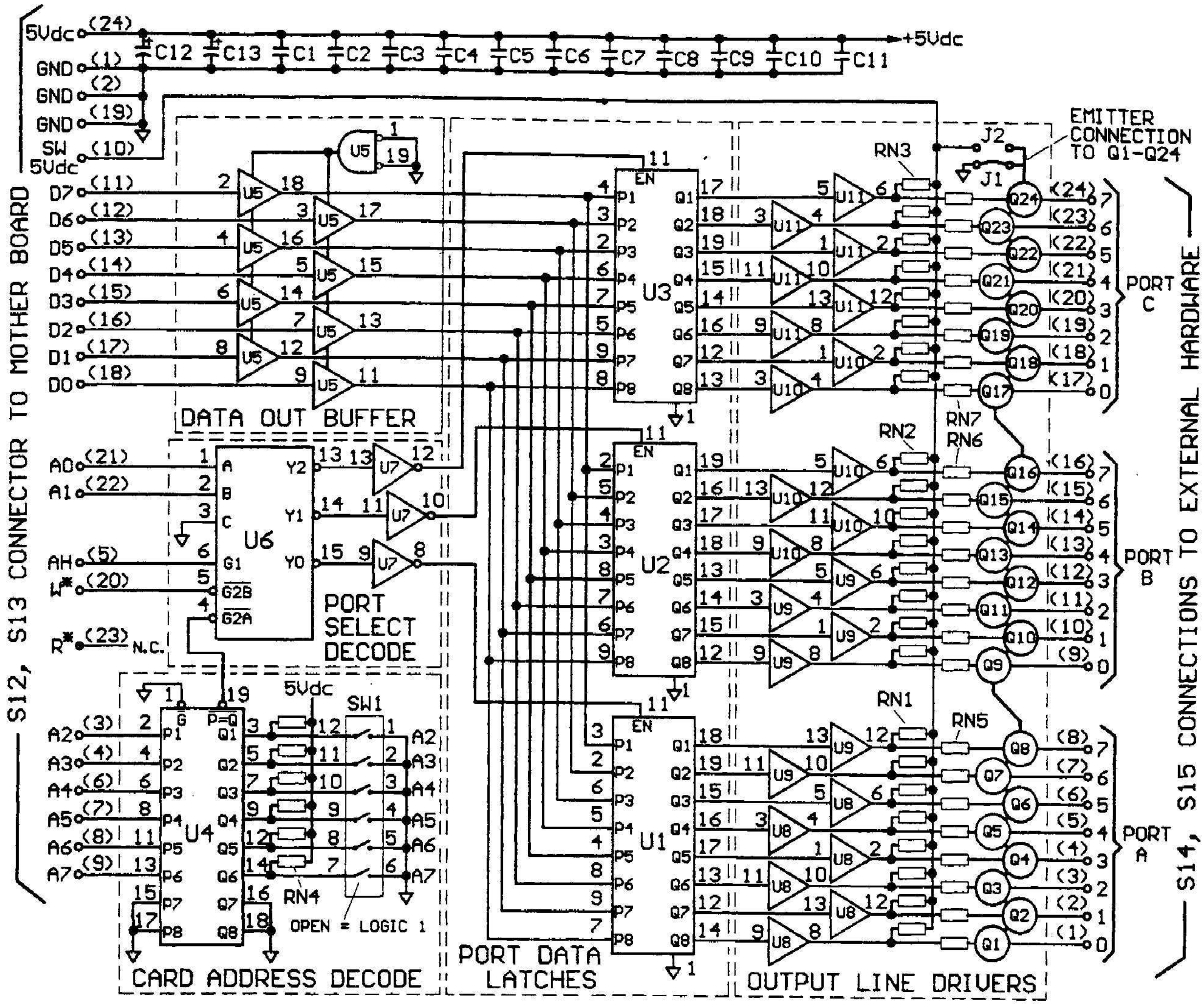


Fig. 17-1. Digital output card schematic (DOUT)

Because of the high level of similarity between the DOUT and DOUT32 schematics I'll mainly focus on the differences presented by the DOUT. For the more complete description refer to the section ***Digital 32-bit Output Card Schematic*** in Chapter 11. For example, the address decode and data out buffer circuits are identical. The Port select decode and the port data latches circuits are identical except that the DOUT card doesn't have port D. This means the only significant difference between the two designs is the output line drivers circuit. The DOUT card includes an added open-collector IC buffer between the each latch output and the drive transistor.

By substituting different transistors and selecting the jumper position as J1 or J2, it is possible to change the type and level of drive capability. Most applications will do exceptionally well with what I call the standard configuration, using the jumper in J1 position and using the specified 2N4401 NPN output transistor. With this you can drive loads requiring up to 40Vdc at .3A. Assuming this configuration meets your needs, you can skip ahead to ***Building the Digital Output Card*** if you prefer.

OPTIONAL DOUT CARD CONFIGURATIONS

It is easy to vary the output configuration to handle special situations. First off, the 7407 hex noninverting driver provides significant latitude in system design. It is an open-collector device that can sink 30mA in the output-low state and can withstand up to 30Vdc in the output-high state. Because it is open collector, we can override the buffer/driver's output as determined by the latch output, and force the 7407's output low via the RN1 pull-up resistor connection to pin 10 of the IOMB or IOMBX.

Fig. 17-2 shows a sub-schematic detailing the latch, buffer/driver, and output transistor portion of the output card configured for both the standard current-sinking and the optional current-sourcing configurations.

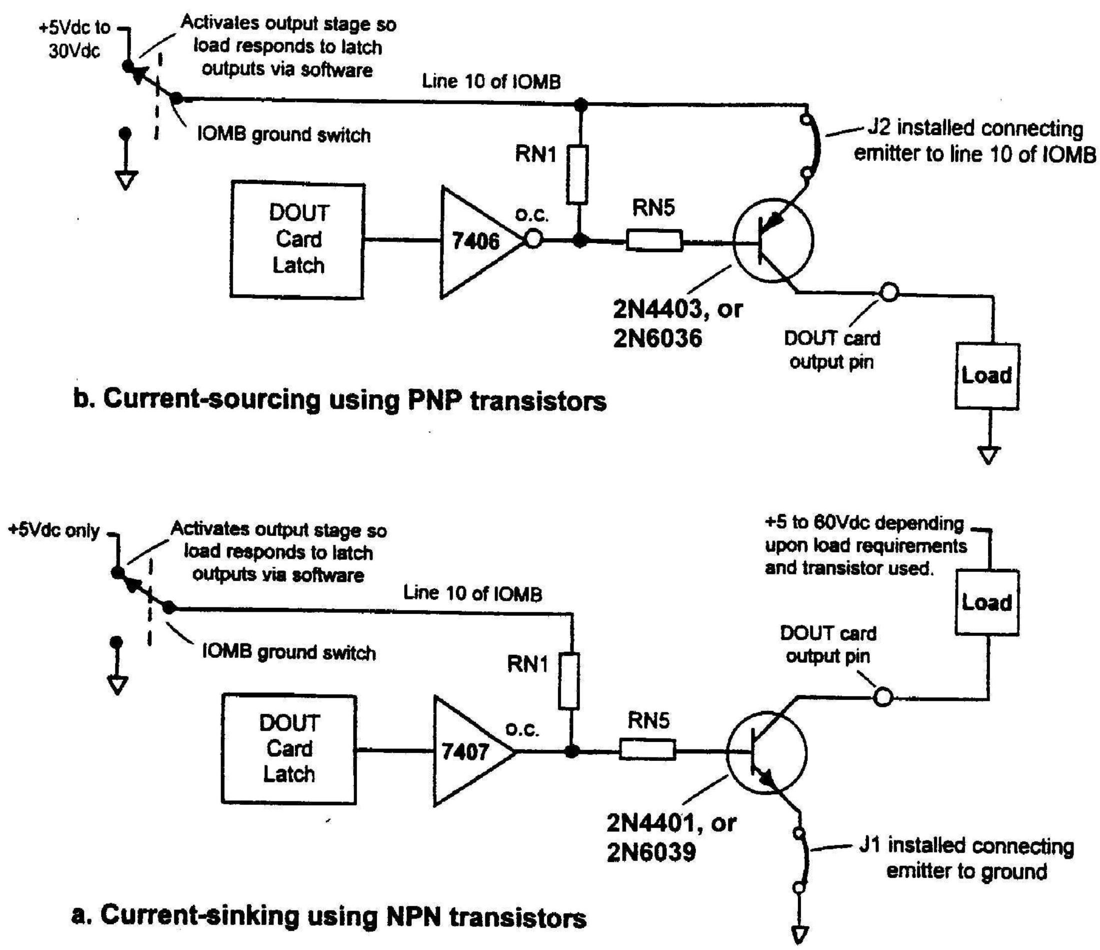


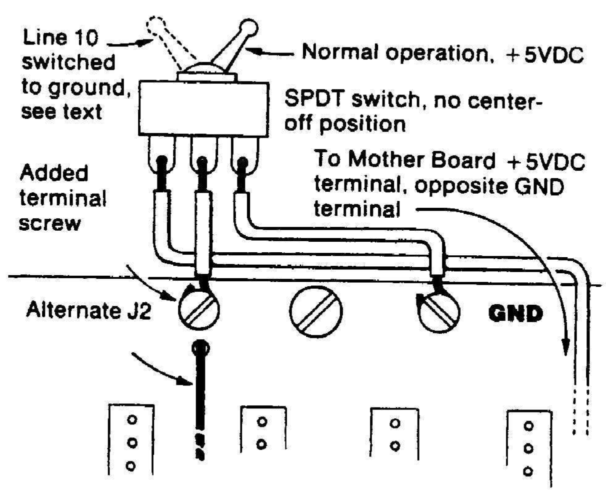
Fig. 17-2. Current-sinking and current-sourcing configurations for DOUT card

Only one output line is illustrated in Fig. 17-2 because all are identical. For readers into circuit design, many different transistors can be used in either configuration and the values of the two resistor networks can be tweaked for specific optimizations. However, the four selections illustrated should handle most every need.

I'll cover the standard current-sinking case first, using the 2N4401 NPN output transistor as shown in Fig. 17-2a. Line 10 on the IOMBX and IOMB is normally connected to +5Vdc. When the output of the latch goes high, the pull-up resistor RN1 pulls the output of the 7407 high. That causes Q1 to conduct and activate the load. When the latch output is low, the output of the 7407 is low, Q1 is turned off and the load is de-activated. Software is used to define the latch output, and therefore we have total control of the load's operation.

When any system is powered up, and particularly when you are program debugging or otherwise changing your program, it's very possible and even likely that you will have loads activated when you do not necessarily want them activated. In many cases this doesn't matter, because the program isn't running in normal operation, but in other applications it might make a difference. When it does, such power-up sequencing problems are typically solved by delaying the turn-on of the external hardware until such time as the software is powered up and has all outputs initialized to the desired starting state.

As an alternative approach, we can change the J2 jumper on IOMBX and IOMB so that it connects line 10 to an optional grounding switch as shown in Fig. 17-3. This way anytime you desire to deactivate the external hardware, that is, turn off all the loads, you simply switch the toggle to the ground position. When line 10 is grounded, it forces the output of the 7407 to ground, causing Q1 to turn off; this switches all the output card signals to the open-circuit state. This action causes all external hardware to de-activate, that is, turn off. For normal operation, turn the toggle to the ON position. It should be pointed out that for this standard current-sourcing configuration, the voltage powering the optional grounding toggle switch remains at the +5Vdc level independent of the voltage applied to the external hardware.



Notes:

1. **Lower end of J2 in alternate position connects to bus line 10 and not to +5Vdc.**
2. **With IOMB, there are holes and corresponding traces built into the board design for the added terminal screw and the alternate J2 location.**
3. **With the IOMBX, the terminal screw and corresponding jumper J2 connection need to be provided for off from the board.**

Fig. 17-3. Optional motherboard ground switch

If you need to drive loads with more than the .3A at 40Vdc capability, substitute a 2N6039 for the 2N4401. This NPN Darlington transistor is a bit trickier to fit on the card, and it's more expensive, but it increases your drive capability up to about 1A and 60Vdc.

The above current-sinking output format should work for most designs. It performs as if the computer interface is a large collection of toggle switches where one side of each switch is connected to ground and the other side is available for connecting to external hardware. Each switch is separately controllable by software giving you total freedom to turn each circuit on and off as desired. This is the preferred method of using digital electronics to drive external hardware.

You may find situations, however, where you need to connect the interface to external hardware that is all prewired with a common ground and what you need to do is switch the hot, or power side, of the loads. These situations can be handled by replacing the NPN transistor with a PNP type, and placing the DOUT card jumper in the J2 position as illustrated in Fig. 17-3b. If you substitute a 7406 inverting buffer/driver in place of the 7407, the circuit retains the same overall logic performance.

In this current-sourcing case, Q1's emitter is connected to the IOMB (or IOMBX) line 10 grounding switch. The voltage applied to the grounding switch must be the same as that powering the loads – but never greater than the 30Vdc limitation of the 7406. With this switch set for the supply voltage and when the output of the latch goes high, the output of the inverter 7406 goes low, causing Q1 to conduct. Having Q1 turned on activates the load. Setting the toggle switch to ground forces the output of the 7406 low but also grounds the emitter of Q1, effectively keeping the load turned off.

The 2N4403 PNP transistor provides a drive capability of .3A and 30Vdc. Changing to the 2N6036 PNP Darlington increases the drive capability to 1A but still at the 30Vdc maximum, the limit of the 7406. Because in the current-sourcing case the sum of all the load currents pass through trace 10 of IOMB (or IOMBX), and for each DOUT through its smaller traces, it's necessary that you control the size of the loads and the number that are turned on simultaneously.

The current-sinking design is more tolerant of driving heavier loads because the ground traces are wider and there are three ground pins per I/O card. Current-sinking also has the distinct advantage that the IOMB (or IOMBX) pin 10 trace remains at the +5Vdc maximum level. When higher voltages are applied, you need to be extremely careful to have each I/O card properly aligned with the IOMB (or IOMBX) headers. Having the connector misaligned by one or more pins will almost certainly result in the higher voltage damaging ICs.

BUILDING THE 24-BIT DIGITAL OUTPUT CARD (DOUT)

Fig. 17-4 is the parts layout and Table 17-1 gives the parts list. All parts mount on the top or A side of the board and are soldered on the B-side. I've indicated steps involving polarity and orientation-sensitive parts with a plus sign in brackets. Here's how to assemble one:

Card test. Use your VOM to check that there are no open-circuit traces and no shorts between adjacent traces or pads.

J1 **or** J2. If building the standard current-sinking configuration, insert the jumper in the J1 position. If building the current-sourcing configuration, then insert the jumper in the J2 position. Solder and trim the leads.

S1-S11[+]. Install the IC sockets with pin-1 orientation as shown in Fig. 17-4.

RN1-RN4[+]. Install these SIP (*S*ingle *I*n-line *P*ackage) resistor networks making sure that the pin 1 end, typically marked with a vertical line or dot, is located toward the right edge of the card as shown in

Fig. 17-4. If unsure of the markings, set your VOM on ohms and find the one end of RN that is common to all the others and you have located pin 1.

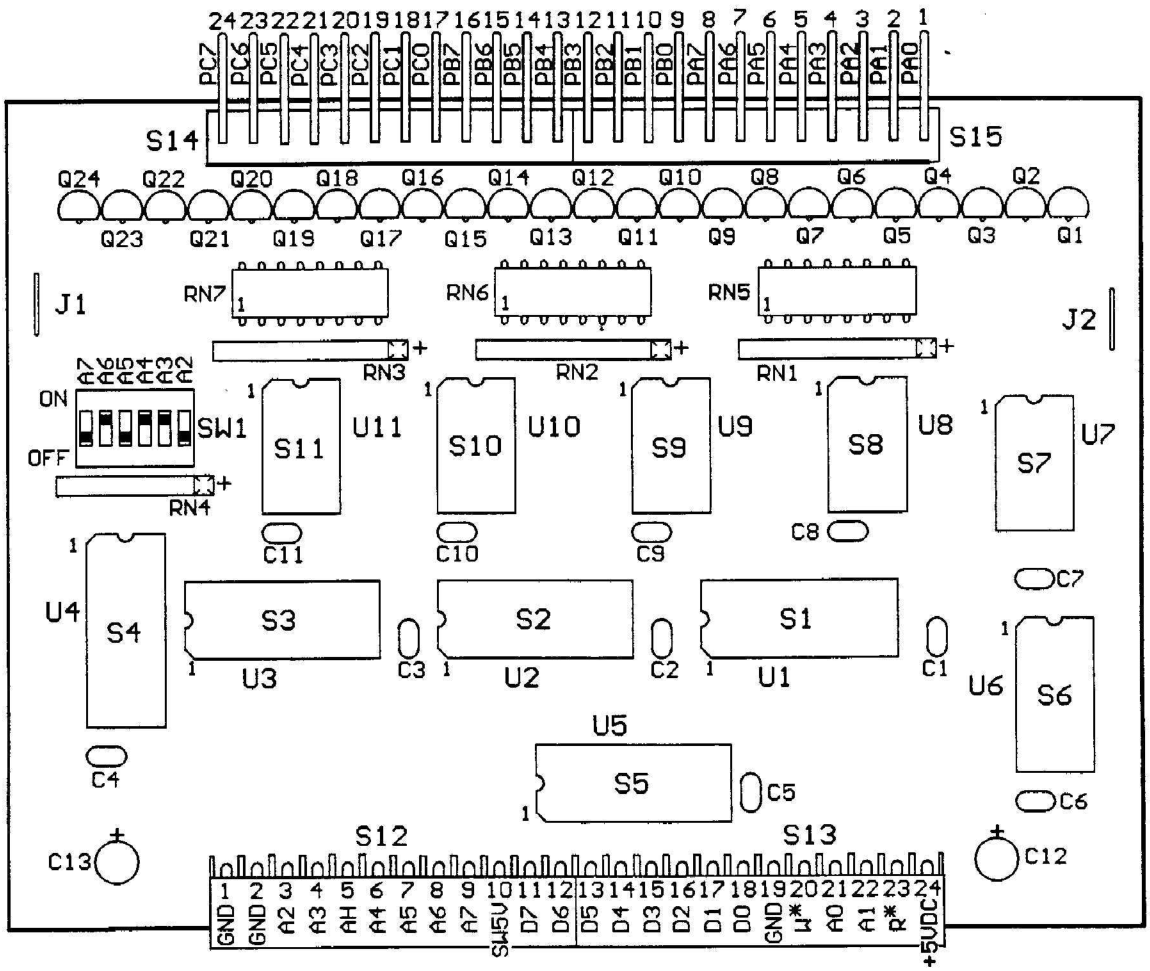


Fig. 17-4. Digital output card parts layout (DOUT)

****Important Point****

For the DOUT card, I now recommend using 2N4401 transistors in place of the previously recommended 2N3904 and 2N4403 transistors in place of the previously recommended 2N3906. The cost differential is only 24 cents per card. The newer transistors provide a more effective “low” when driving heavier loads. Also, the newer transistors require less drive which substantially lowers the current draw per card. However, if you have spare 2N3904 or 2N3906 transistors and you elect to use them with DOUT, you also need to change RN1-RN3 SIP resistor networks back to their original 1KΩ value and the RN5-RN7 DIP resistor networks back to their original 120Ω value.

RN5-RN7. Install these DIP (*D*ual *I*n-line *P*ackage) resistor networks as shown in Fig. 17-4. Orientation isn’t important but for consistency in appearance, its best to align them just like the ICs. (To reduce cost, you can substitute 24 separate resistors and install them in place of the DIP networks.)

SW1[+]. Use your VOM to make sure you install this DIP switch so its contacts are closed when thrown toward U4. This may well make the switch read like it is upside down, but this orientation is absolutely critical to setting correct card addresses. Also, for readers who may have assembled the original-design I/O cards (as covered in Appendix F), this closed-switch orientation is opposite.

S12, S13. Install the 12-contact side entry connectors by first hooking their nylon retaining fingers over the edge of the card, then feeding the metal contact pins through the card holes. Make sure all 12 pins of each connector pass through the holes. Hold the connector shell tightly against the card as you solder.

S14, S15. Install the 12-prong right angle headers and hold them tightly against the card as you solder. Use the same procedure as with the headers on IOMB and IOMBX to insure that each base is pressed firmly against the card.

Table 17-1. Digital Output Card parts list (DOUT)

Qnty.	Symbol	Description
1	J1 **or** J2	Install long jumper using standard current-sinking or J2 jumper when using current-sourcing. (make from spare ends of resistor leads)
5	S1-S5	20-pin DIP sockets (Jameco 112248)
1	S6	16-pin DIP socket (Jameco 112221)
5	S7-S11	14-pin DIP sockets (Jameco 112213)
3	RN1-RN3	4.7KΩ 9-element SIP resistor networks (Jameco 24660)
1	RN4	2.2KΩ 7-element SIP resistor network (Digi-Key 777-81-R2.2K)
3	RN5-RN7	470Ω 8-element DIP resistor networks (Jameco 24660)
1	SW1	6-segment DIP switch (Digi-Key CT2066)
2	S12, S13	12-pin Waldom side entry connectors (Mouser 538-09-52-3121)
2	S14, S15	12-pin Waldom right angle headers (Mouser 538-26-48-1122) or substitute a single 24-pin right angle header (Mouser 538-26-48-1242)
11	C1-C11*	.1μF, 50V monolithic capacitors (JDR .1UF-MONO)
2	C12, C13*	2.2μF, 16V tantalum capacitors (Jameco 94001)
24	Q1-Q24	2N4401 NPN small signal transistors (Jameco 38421)
3	U1-U3	74HCT573 octal D-type latched flip-flops (Jameco 45090)
1	U4	74HCT688 8-bit Magnitude comparator (Jameco 45129)
1	U5	74LS541 octal buffer/line driver (Jameco 47870)
1	U6	74LS138 3-to-8 decoder (Jameco 46607)
1	U7	74LS04 hex inverter (Jameco 46316)
4	U8-U11	7407 hex buffer/drivers w/open collector output (Jameco 49120)
		Alternate parts for higher current NPN current-sink configuration (see text)
24	Q1-Q24	2N6039 NPN Darlington transistors (Mouser 511-2N6039)
		Alternate parts for standard current PNP current-source configuration (see text)
24	Q1-Q24	2N4403 PNP small signal transistors (Jameco 38447)
4	U8-U11	7406 hex inverting buffer/drivers w/open collector output (Jameco 49091)
		Alternate parts higher current PNP current-source configuration (see text)
24	Q1-Q24	2N6036 PNP Darlington transistors (Mouser 511-2N6036)
4	U8-U11	7406 hex inverting buffer/drivers w/open collector output (Jameco 49091)
		Mating connector for cable
2	—	12-pin Waldom terminal housing (Mouser 538-09-50-3121)
24	—	Crimp terminals (Mouser 538-08-50-0106 for wire sizes 18-20 or 538-08-50-0108 for wire sizes 22-26)

Author's recommendations for suppliers given in parentheses above with part numbers where applicable. Equivalent parts may be substituted, however if you substitute capacitors, make sure they have .098" (or 2.5mm) lead spacing (as denoted by asterisk above).

Execute only one of the following two steps, depending upon which configuration you are building. Have the board oriented as in Fig. 17-4 and refer to Fig 17-5 when installing these parts.

Q1-Q24[+]. These instructions are for the 2N4401 if J1 installed, and the 2N4403 if J2 installed. Slightly bend the leads of each transistor to fit its holes, and orient each with its flat side facing the resistor networks with its center (base) lead in the hole nearest the resistors. For a neat installation with Q1-Q24 all lined up in a row, I put a spacer of 1/8-inch-square stripwood under the curved back sides of the transistors, then press each one down until it just rests on the wood. Once all 24 transistors are soldered in place, I remove the wood and trim the leads.

Q1-Q24[+]. These instructions are for the 2N6039 if J1 installed and the 2N6036 if J2 installed. Referring to Fig. 17-5, you'll need to bend the leads of each transistor quite extensively to fit its holes, making certain that you have the emitter lead in the emitter hole, the collector lead (the center lead on the transistor) in the collector hole and the base lead in the base hole, nearest the resistors. The base lead requires the most bending and forming. The transistors will end up on about a 45-degree angle, and with the metal tab facing the upper right corner of the board. Solder and trim the leads.

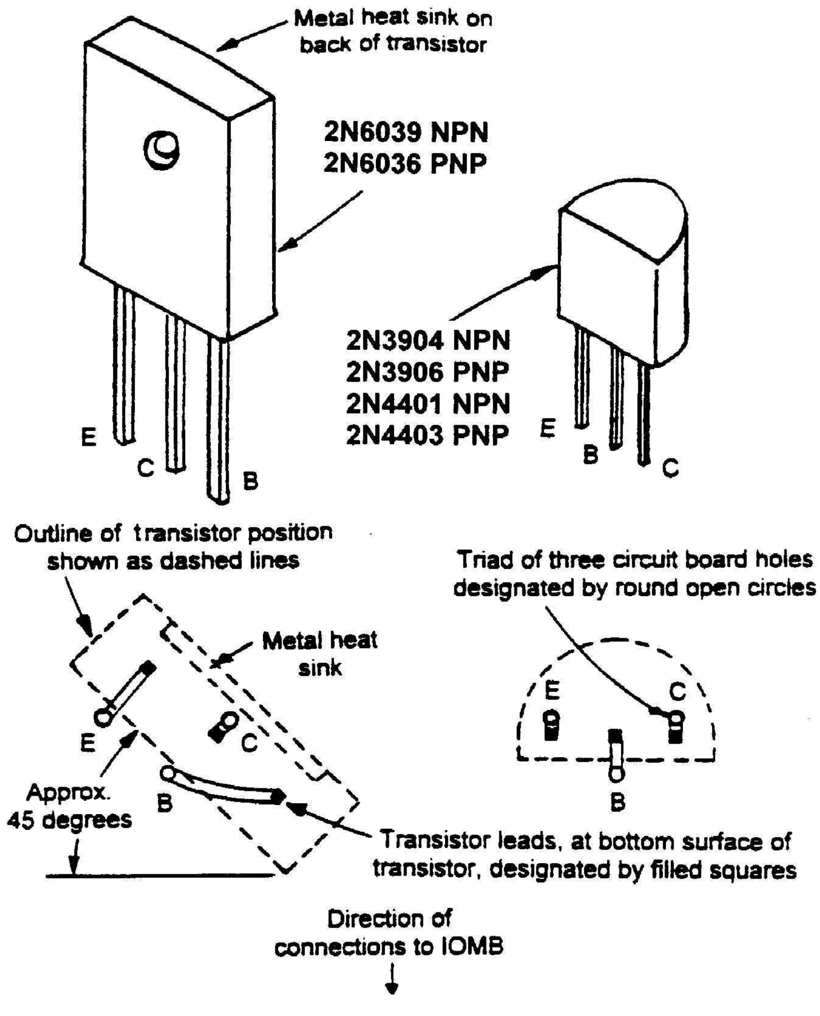


Fig. 17-5. Installing transistors on the DOUT card.

C1-C11. Insert, solder, and trim leads.

C12, C13[+]. Install these capacitors with their plus (+) leads in the plus holes as indicated in Fig. 17-4. Reversed polarity will damage the capacitors.

U1-U11[+]. See Fig. 1-7 for IC insertion and extraction procedures. Be sure you have the ICs specified, that you put them in the right sockets with correct pin-1 orientation, and that all pins go into the socket. Be sure for U8-U11 you are using the 7407 if J1 is installed and 7406 if J2 is installed.

Cleanup and inspection. To help insure your card functions properly, follow the specific steps covered in Chapter 1 regarding cleanup and inspection. This is a most vital step so don't cut it short!

That completes the DOT card. I'll discuss the DIN card's schematic next, but if you wish you may skip ahead to ***Building the Digital Input Card (DIN).***

DIGITAL 24-BIT INPUT CARD SCHEMATIC (DIN)

Fig. 17-6 is the schematic for the digital input card (DIN).

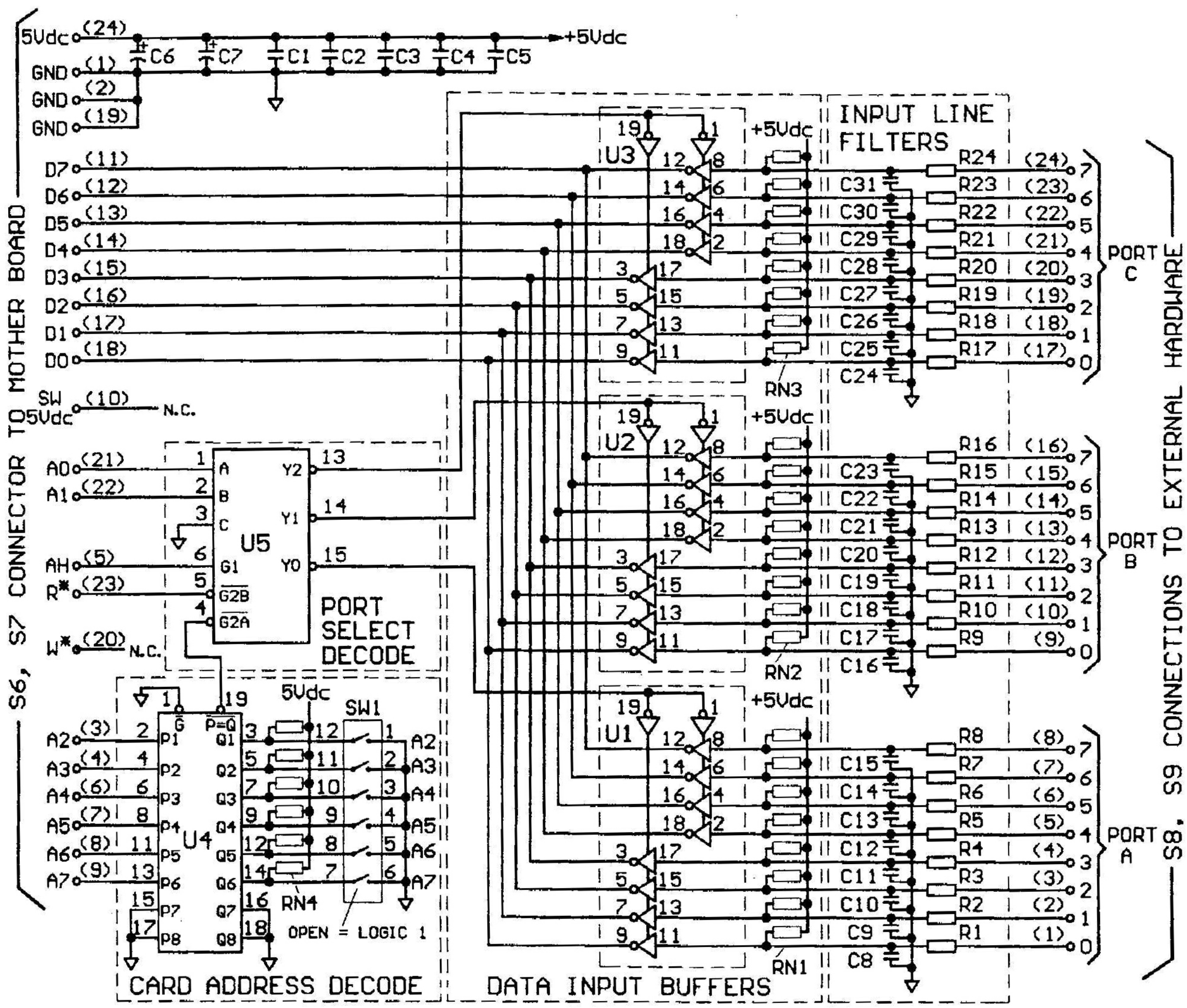


Fig. 17-6. Digital input card schematic (DIN)

The card address decode section is identical to that of the output card; the only difference in the port select decode is that the R* line is connected to pin 5 of U5 instead of the W* line. Also, no latching is required on inputs since once the computer has performed the READ operation, the data read is stored in memory.

Three 74LS240 octal tri-state inverting bus drivers, U1-U3, are used to connect each of the three input ports to the data bus. Tri-state is important so we don't have multiple chips trying to each connect up to the bus at the same time.

The pin 1 and 19 inputs on U1-U3 are normally high, and the devices are held in their tri-state, open circuit condition. Only when pins 1 and 19, for one of the buffer/drivers, is brought low by the appropriate output of the port select decode is the input data from the external hardware transferred to the C/MRI data bus.

Pull-up resistors, in the form of resistor networks RN1-RN3, are provided to normally hold each of the data input lines high at the 5Vdc level. To signal an input, the external hardware needs only to pull the input line to ground. I prefer to use the inverter form for buffer/drivers U1-U3 so that when an input line is activated (pulled-to-ground), the action shows up as logic 1 in the software. This is the way all the software is written in this manual. However, if you prefer the opposite approach, simply replace U1-U3 with their noninverting counterpart, a 74LS244, and rewrite the software accordingly.

The DIN card is designed so that each input line is wired from the external hardware directly into the appropriate pin on U1-U3. This works great for most applications, and is how the original-design input cards function. However, the interface-input lines emanating from many hardware applications contain extensive electrical noise. Adding a noise filter to each input line can reduce the effects of such noise. If you are not interested in this option, simply skip ahead to the section on ***Building the Digital Input Card.***

OPTIONAL INPUT LINE FILTERING – DIN CARD

Adding a low-pass RC (*R*esistor-*C*apacitor) filter circuit to each input line is accomplished with DIN in the same manner used with the DIN32 card. The only difference is that there are only 24 input lines rather than 32. For details on input line filtering and its application, see section ***Optional Input Line Filtering – DIN32 Card*** in Chapter 11.

BUILDING THE 24-BIT DIGITAL INPUT CARD (DIN)

Fig. 17-7 gives its parts layout and Table 17-2 the parts list. Here's how to build one:

Card test. Use your VOM to check that there are no open-circuit traces and no shorts between adjacent traces or pads.

S1-S5[+]. Install the IC sockets with pin-1 orientation as shown in Fig. 17-7.

RN1-RN4[+]. Install these SIP (*S*ingle *I*nline *P*ackage) resistor networks being careful to have the correct pin 1 orientation. Solder and trim leads.

SW1[+]. Use your VOM to make sure you install this DIP switch so that its contacts are closed when thrown toward U4. This may well make the switch read like it is upside down, but this position is absolutely critical to setting correct card addresses. Also, for readers who may have assembled the original-design I/O cards (as covered in Appendix F), this switch orientation is opposite.

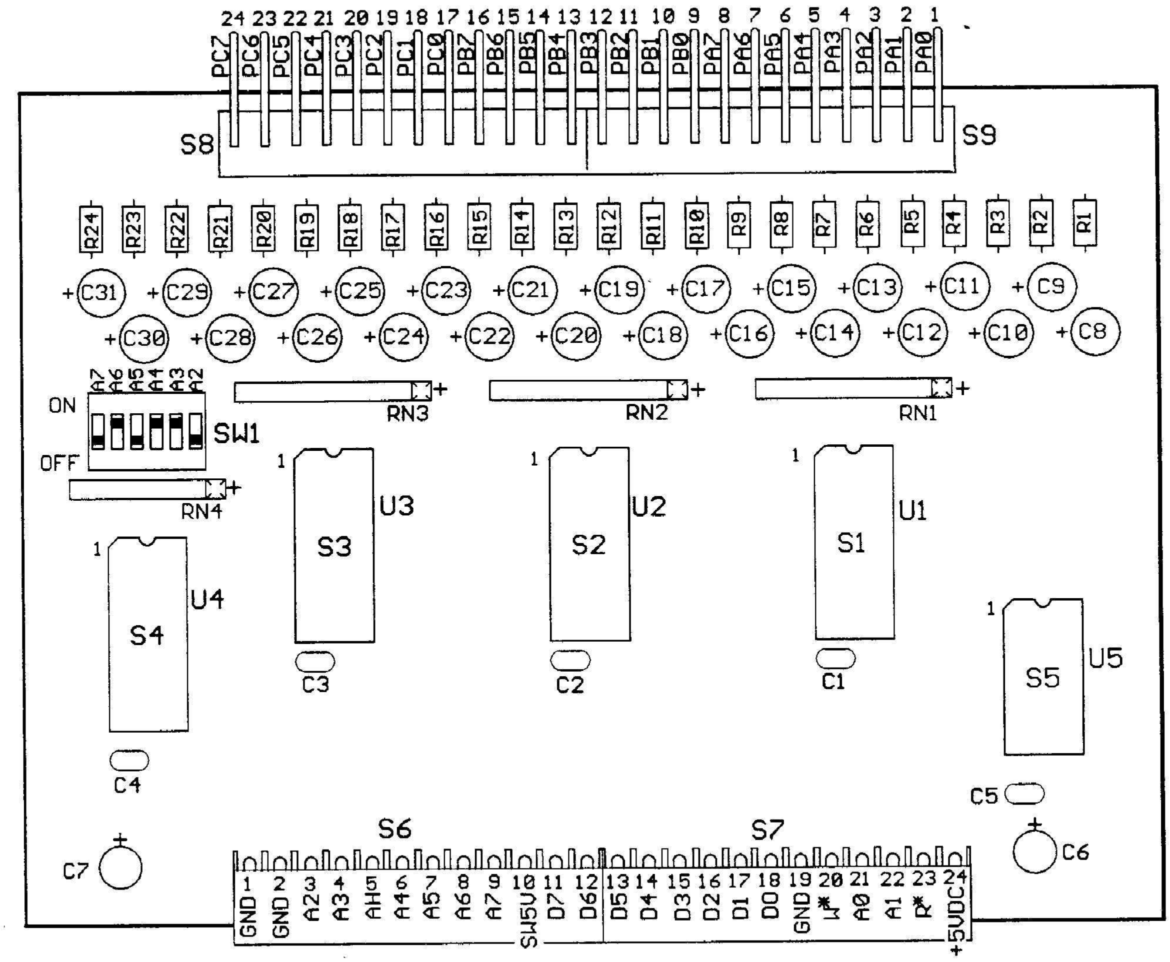


Fig. 17-7. Digital input card parts layout (DIN)

S6, S7. Install the 12-contact side entry connectors by first hooking their nylon retaining fingers over the card edge, then feeding the metal contact pins through the card holes. Make sure all 12 pins of each connector pass through the holes. Hold the connector shell tightly against the card as you solder.

S8, S9. Install the 12-pin, right angle headers, and hold them tightly against the card as you solder. Use the same procedure as with the connectors on the IOMB and IOMBX to insure that each base is pressed firmly against the card.

C1-C5. Insert these components, solder, and trim leads.

C6-C7[+]. Install these capacitors with their plus (+) leads in the plus holes. Reversed polarity will damage the capacitors.

Table 6-2. Digital Input Card parts list (DIN)

Qnty.	Symbol	Description
4	S1-S4	20-pin DIP sockets (Jameco 112248)
1	S5	16-pin DIP socket (Jameco 112221)
3	RN1-RN3	2.2KΩ 9-element resistor networks (Jameco 97893)
1	RN4	2.2KΩ 7-element resistor network (Digi-Key 770-81-R2.2K)
1	SW1	6-segment DIP switch (Digi-Key CT2066)
2	S6, S7	12-pin Waldom side entry connectors (Mouser 538-09-52-3121)
2	S8, S9	12-pin Waldom right angle headers (Mouser 538-26-48-1122) or substitute a single 24-pin right angle header (Mouser 538-26-48-1242)
5	C1-C5*	.1µF, 50V monolithic capacitors (JDR .1UF-MONO)
2	C6, C7*	2.2µ, 16V tantalum capacitors (Jameco 94001)
3	U1-U3	74LS240 octal inverting buffer/drivers (Jameco 47141)
1	U4	74HCT688 8-bit Magnitude comparator (Jameco 45129)
1	U5	74LS138 3-to-8 decoder (Jameco 46607)

Fixed resistor and most popular alternate capacitors for different levels of filtering (see text)

24	R1-R24	100Ω resistors [brown-black-brown]
24	C8-C31	.1µF, 35V tantalum capacitor (Jameco 33486)
24	C8-C31	.1µF, 50V monolithic capacitors (JDR .1UF-MONO)
24	C8-C31	1µF, 35V tantalum capacitor (Jameco 33662)
24	C8-C31	10µF, 16V tantalum capacitor (Jameco 94060)
24	C8-C31	22µF, 16V radial lead electrolytic capacitor (Digi-Key P6224)
24	C8-C31	47µF, 16V radial lead electrolytic capacitor (Digi-Key P6226)
24	C8-C31	100µF, 16V radial lead electrolytic capacitor (Digi-Key P6227)

Note: Lead spacing for capacitors should be between .079”(2mm) and .1” (2.5mm)

Mating connector for cable

2	—	12-pin Waldom terminal housing (Mouser 538-09-50-3121)
24	—	Crimp terminals (Mouser 538-08-50-0106 for wire sizes 18-20 or 538-08-50-0108 for wire sizes 22-26)

Author’s recommendations for suppliers given in parentheses above with part numbers where applicable. Equivalent parts may be substituted.

Skip the next 4 steps unless including input line filtering.

Cut traces on the bottom side of the board in the necked-down thin-area right under the center of each resistor location. Use an X-Acto knife or a cut-off wheel in a Dremel™-type hand power tool. The cut should be at lease 1/32-in wide and need not be any deeper than the trace itself.

Use your VOM to make sure that you have an open circuit across each of the cuts.

R1-R24. Install, solder and trim leads.

C8-C31[+]. Install with the value of your choice per Table 6-2 and corresponding text discussion in Chapter 11. For those that are polarity sensitive (tantalum and electrolytic) make sure their plus (+) leads go into the plus holes.

U1-U5[+]. Be sure you have the ICs specified, that you put them in the right sockets with correct pin-1 orientation and that all pins go into the socket.

Cleanup and inspection. To help insure your card functions properly follow the specific steps covered in Chapter 1 on cleanup and inspection. This is a most vital step so don't cut it short!

This completes the assembly of the general-purpose digital input card.

BUILDING THE 24-BIT DIGITAL OUTPUT TEST CARD (DOTEST)

The standard test card for the 24-bit DOUT and DIN cards is the DOTEST card. However, you can use the newer TEST32 card in place of the DOTEST. Ready to assemble DOTEST cards are available from JLC Enterprises and fully assembled and tested cards or complete kits, are available from EASEE Interfaces. See Appendix A for details.

The LEDs on DOTEST display the status of each of the 24 output lines at any time. This makes initial checkout of 24-bit based nodes a snap and can also come in handy any time you need to debug the C/MRI or confirm that it's operating properly.

There's an extra set of pads on the DOTEST card, marked A1, A2, etc. such that if the corresponding pads are connected using insulated jumpers and the underside traces are cut, the card tests the original-design COUT24 card covered in Appendix F. For this chapter we can simply ignore these extra pads.

Fig. 17-8 shows the parts layout for DOTEST and Table 17-3 the parts list. I'll just name those assembly steps similar to those you've already performed on other cards, and give details on anything new.

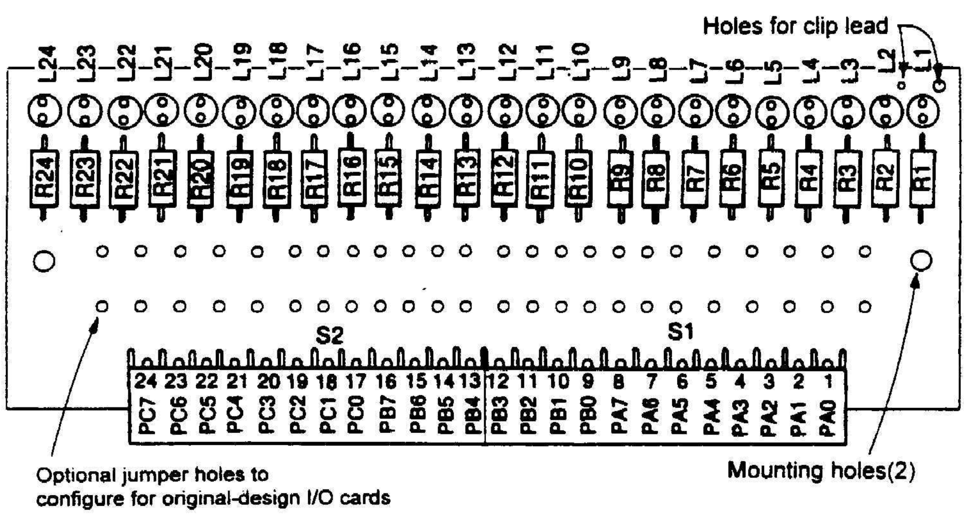


Fig. 17-8. Digital output test card parts layout (DOTEST)

Card inspection.

S1, S2.

Panel Plate. Make the LED display panel as shown in Fig. 17-9. You can lay a photocopy of the panel face, Fig. 17-10, over the aluminum and punch through the paper to mark the metal for drilling. Or if you can't find aluminum handy, a piece of .06 inch thickness styrene sheet (available at most hobby shops) will work fine.

Table 17-3. Digital output test card parts list (DOTEST)

Qnty.	Symbol	Description
24	R1-R24	330Ω resistors [orange-orange-brown]
2	S1, S2	12-pin Waldom side entry connectors (Mouser 538-09-52-3121)
24	L1-L24	Red diffused T1 size LEDs (Digi-key P363)
2	—	¼"-diameter x ¼"-long standoffs (Digi-Key J167)
2	—	4-40 x ½" pan-head machine screws (Digi-Key H146)
2	—	4-40 hex nuts (Digi-Key H216)
1	—	Clip lead (Jameco 10444)
1	—	1/16" x 1¼" x 5" aluminum (or styrene) LED panel

Author's recommendations for suppliers given in parentheses above with part numbers where applicable. Equivalent parts may be substituted. Resistors are ¼W, 5 percent and color codes are given in brackets.

L1-L24, positioning [+]. Install the LEDs with the positive leads in the holes next to the top of the card and the negative leads in the holes next to the resistors. Fig. 17-9 shows how to identify LED leads. DO NOT solder the LEDs at this time.

Panel assembly. Mount the panel on the card as in Fig. 17-9, carefully working each LED into its panel hole.

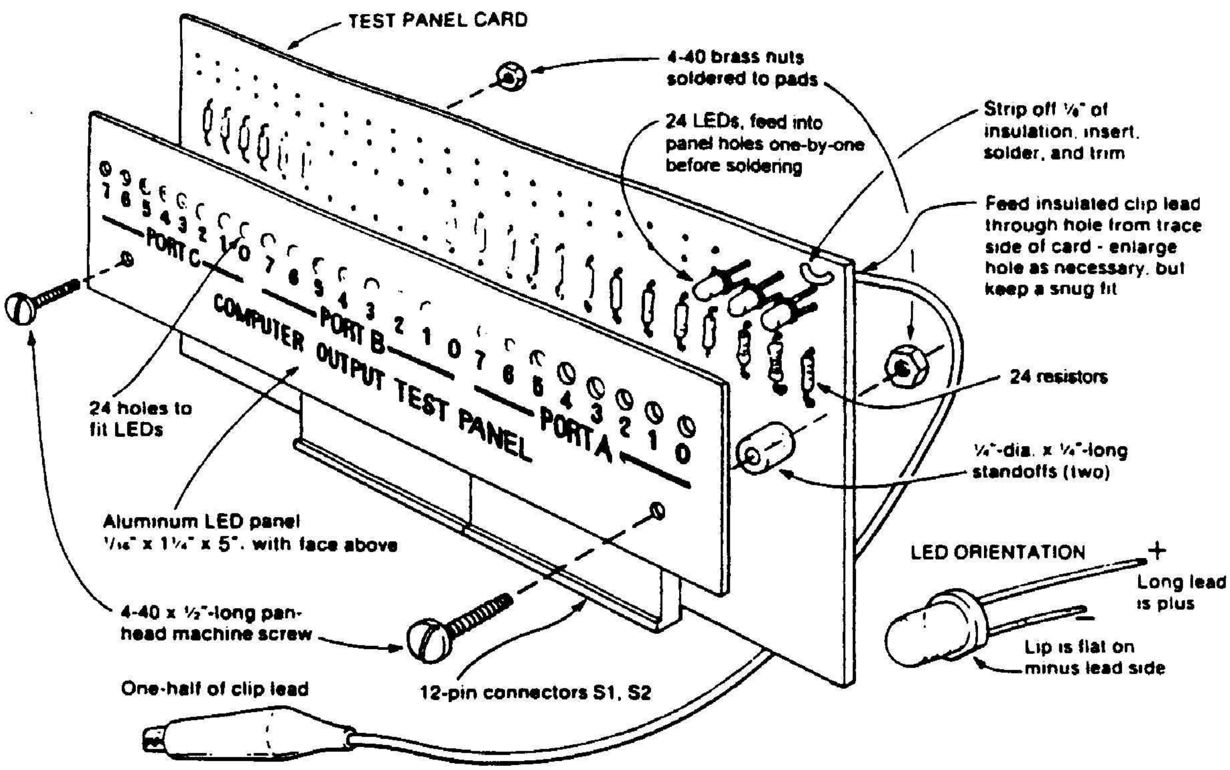


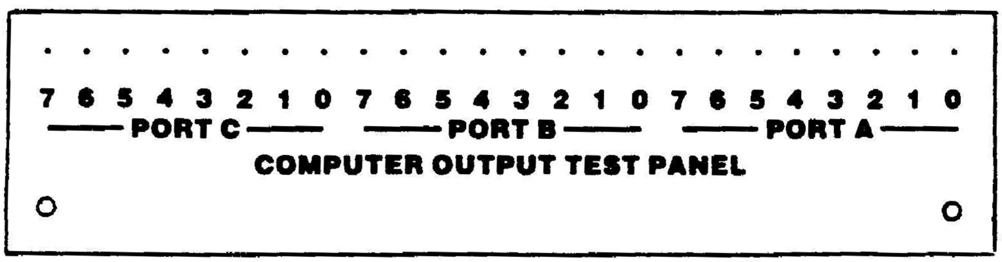
Fig. 17-9. Digital output test card assembly (DOTEST)

L1-L24, soldering. One at a time, push the lip of each LED firmly against the panel, then solder and trim the leads. Solder the two 4-40 brass nuts to their circuit board pads.

Clip lead. Cut a clip lead in two, leaving one end about 12 inches long. Strip off 1/8-in of insulation from the cut end and install as shown in Fig. 17-9.

Cleanup and inspection.

Panel face. Cut the panel face out of Fig. 17-10 or a photocopy. Dismount the panel and use spray adhesive to cement the face to it with the dots centered over the holes. Use an X-Acto™ knife with a No. 11 blade to trim excess paper off the edges, then work from the face side to trim out the 26 holes. Remount the panel.



Actual size panel face

Fig. 17-10. Digital output test panel artwork (DOTEST)

Card test. Attach the card's clip lead to the +5Vdc terminal of your power supply. Attach another clip lead to the ground terminal and, with the supply turned on, touch its other end to each of the 24 connector inputs. Only one LED should light for each input, and their order should exactly correspond to the connector pinout. If more than one lights you have a solder bridge. If one doesn’t light you have a poor solder joint, a bad LED, or a reversed LED. Debug until all 24 LEDs work correctly.

If you need to test a number of DOUTs configured as current-sources, you can build up a second test card with the LEDs installed the opposite way. Then when you conduct the test you’ll connect the clip lead to ground rather than +5Vdc. I substituted green LEDs for my current-sourcing test card.

This completes the assembly and test of the DOTEST card. We’ll use software to test both the DOUT and DIN cards following the same procedures used back in Chapter 6.

IN CASE OF DIFFICULTY

If you run into difficulty testing the DOUT and DIN cards, the procedures presented in Chapter 6 should lead you to correct solutions. However, because of the different IC configurations there are differences in the IC power and DIP switch testing.

DOUT card power test. Turn off the +5Vdc supply and plug the output card into any IOMB or IOMBX slot. Turn the power back on and follow Table 17-4 to see that power reaches each IC. If the voltage is way too low, your output card probably has a short circuit. Look for and correct reversed polarity-sensitive capacitors, ICs backwards, and/or solder bridges. If necessary, remove ICs one at a time, turning power off and on each time, to help isolate the problem.

DOUT card DIP Switch test. Connect your (-) meter lead to ground and move the (+) lead to touch the IC pins listed in Table 17-5. At each position move the corresponding switch segment ON and you should read +5Vdc and to OFF measure 0Vdc. If all readings are reversed you have the switch in backwards. If only some segments are incorrect, check around for poor soldering or a faulty switch.

DIN card power test. Turn off the +5Vdc supply and plug the output card into any IOMB or IOMBX slot. Turn the power back on and follow Table 17-6 to see that power and ground reach each IC. If the voltage is way low, your output card probably has a short circuit. Look for and correct reversed polarity sensitive capacitors, backward ICs and/or solder bridges. If necessary, remove ICs one at a time, turning power off and on each time, to help isolate the problem.

Table 17-4. Digital Output Card IC Power Tests (DOUT)

	IC	+ METER LEAD ON PIN No.	– METER LEAD ON PIN No.
	U1	20	10
	U2	20	10
	U3	20	10
	U4	20	10
	U5	20	10
	U6	16	8
	U7	14	7
	U8	14	7
	U9	14	7
	U10	14	7
	U11	14	7

Each line should read +5Vdc

Table 17-5. DOUT and DIN card DIP switch tests

	IC	PIN No.	DIP SWITCH SEGMENT
	U4	3	A2
	U4	5	A3
	U4	7	A4
	U4	9	A5
	U4	12	A6
	U4	14	A7

With switch segment set to”ON” IC pin should read +5Vdc
With switch segment set to”OFF” IC pin should read 0Vdc

Table 17-6. Digital Input Card IC power tests (DIN)

	IC	+ METER LEAD ON PIN No.	– METER LEAD ON PIN No.
	U1	20	10
	U2	20	10
	U3	20	10
	U4	20	10
	U5	16	8

Each line should read +5Vdc

DIN card DIP switch test. Connect your (-) meter lead to ground and move the (+) lead to touch the IC pins listed in Table 17-5, the same as for DOUT. At each position move the corresponding switch segment ON and you should read +5Vdc; in the OFF position you should measure 0Vdc.