DIGITAL GROUP 6502/6800 CPU CARD

General Design

The CPU Card is the central component of the Digital Group Microprocessor Systems. Each CPU Card contains the CPU IC, in this case a 6502 or a 6800, 2K bytes of RAM, a 256 byte Erasable Read Only Memory (EROM), and miscellaneous drivers, decoders, and gates.

This Digital Group CPU card also contains "ANY Interrupt OR" circuit for advanced applications if desired.

Full Direct Memory Access (DMA) is standard on this Digital Group card. DMA capability provides a convenient means for attaching a front panel for direct data loading into memory from switches. High speed data storage devices such as disks can directly load memory by operating its interface under DMA. Parallel processors can use the same memory shared under DMA.

Buffering is included on this board to permit driving a full memory system (65K bytes) and I/O ports. Miscellaneous logical CPU functions such as Power On Reset and Single Stepping are provided.

The Digital Group System architecture is based an a CPU independence design constraint. This means that the same set of hardware I/O and memory related components may be driven by a number of different CPU and CPU structures. The user may upgrade or benchmark systems by merely exchanging CPU cards. All CPU dependencies are handled on the CPU card. A bus structure giving a separate I/O bus and memory bus provides support for several current microprocessor architectures, and future designs.

Since the Digital Group Systems are I/O and application intensive designs, the EROM provides a convenient way to initialize the system at power on, by using a low cost cassette. Use of an EROM allows customized initialization by sophisticated users able to program their own EROMs.

2K bytes of Random Access Memory (RAM) give sufficient storage for a small operating system allowing the user to Read and Write cassettes, and Key in data and programming from an ASCII keyboard and Dump Storage contents on an attached TV monitor. A small amount of storage is available to the user for small dedicated programs, or additional memory is available from the Digital Group to support more extensive applications.

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"6000 Series" CPU Description

The Digital Group "6000 Series" CPU card may be logically divided into six interrelated design groups. They are CPU and immediate "housekeeping" logic, Run control, DMA, Interrupt, Buffering, and Memory. The CPU and immediate housekeeping consists of the 6502 or 6800, separate clock generator (for 6800 only), Read/Write and Memory/I/O cycle decode, and an I/O port address bus driver/decoder. This CPU card has the I/O ports assigned to addresses 376 000 (FE 00) to 376 377 (FE FF), `giving 256 potential I/O ports.

The newer 6502's and 6800 require an external 1 MHz 2 phase oscillator. This external oscillator is provided by IC's 52, 35, and 37. In addition, jumpers are required to select 6800 operation, or 6502 operation.

Two sections of 74L04 (IC52) are used as an external crystal oscillator when using a 6502 or 6800 with this CPU board. The other four sections provide a fixed signal delay. The 75451 (IC35)and a 7400 (IC37) to provide the two phases of the non-overlapping clock when using a 6800. The 75451 provides the very fast rise and fall time required by the 6800.

If using the 6502 in this board, IC's 35, and 37 must be out of their sockets. When using a 6800, the 74121 (IC25) must be out.

A Power On Reset function is provided. An external switch is attached for remote "reset and go" operation. A 4013 provides a delayed reset pulse when power is turned on. The system may also be subsequently reset to a known programming condition by pressing the remote Reset switch.

A 7442 (IC28) handles all of the function decoding to enable memory reading and writing at the proper time, Input port reading, and Output port writing. The input lines to this 7442 are slightly delayed as well as gated to avoid data glitches.

Run Control logic permits single stepping a 6502 through a program if a front panel readout is provided for viewing the resulting instruction sequencing. In addition, Wait Stating for slow external memory and the EROM access delay is provided. The single step data latch is reset by the gated sync pulse if using a 6502. A 6800 in this board has the single step reset when it is clocked through the 7474 (IC30).

Single step in the 6502 steps on the instruction (which may be 1, 2, or 3 bytes long). Unfortunately, the 6800's address and data lines go high impedence when the Ready line is dropped to single step. This means that the typical simple front panel is of no use when using 6800, but requires special latching.

2/4 of a 7402 (IC40) are used as a Run latch. When the step switch is activated, the Run latch is reset, and the 1/2 74123 (IC46) fires a 50 ms pulse to debounce the switch. The resultant pulse is held in the 1/2 7474 (IC30) for a very short time until syncronized to $\phi 1$ and acknowledged. The 1/4 7402 (IC40) OR gate couples the Continuous Run or the Step pulse. A 7410 (IC39) gate, and a 1/2 7474 (IC38) will then drop the Ready line if either no run command, continuous or step, exists, a DMA Granted state has occured, or a "Wait" command goes high.

If no "Single Step" Operation is to be used, tie pin 43 to +5 externally.

DMA consists of sections of IC's 36, 38, and 40. DMA is organized as an external request for control of memory and the granting of this request as soon as the CPU can safely grant the request without current data loss. The rise time of the DMA Request line sets 1/2 7474 (IC38) into a request pending state. After 8 $\phi 1$ cycles, the pending status is accepted and the DMA request is granted. The CPU operations are suspended, the various drivers (the 8T97 IC's) go to a high impedence state, and the external circuitry making the request is allowed full control over memory.

DMA Request and Grant is ended by a Reset function ending, which allows normal CPU processing to resume. If DMA is not required, the pulldown resistor (470Ω) allows simply not connecting anything to the DMA Request line at pin 40.

Interrupt control is handled by IC's 26,27 and 45. The 7407's are open collector buffers with their collectors wired in parallel. 1/2 4013 provides a debounced pulse for a keypressed interrupt if desired.

6502 and 6800's have two different kinds of interrupt capability, NMI and IRQ. IRQ is the general interrupt input to these CPU's. The CPU may respond to a negative going signal on the IRQ line if a software "Interrupt Enable" has been previously issued. The CPU will then proceed under software control to determine the nature of the interrupt. NMI (Non-Maskable Interrupt), on the other hand, will cause an interrupt , to proceed under software control, but the CPU will be forced to proceed with interrupt processing. An NMI will occur regardless of whether Interrupts are enabled by an "Interrupt Enable" or not.

The 7407 outputs are connected to the IRQ line; the NMI is brought out directly. However, the user may reverse these assignments by using some included reversal pads.

The Digital Group CPU's are designed to drive a full complement of memory and I/O. In addition, the CPU's are designed to operate under Direct Memory Access as mentioned previously, and tri-state buffers permit isolating the CPU from the attached and auxiliary memory.

2 4/6 8T97's provide buffered address outputs from the CPU, capable of each driving 30 TTL loads. These drivers handle both memory and I/O port addressing. DMA Grant is connected to these drivers so that when a DMA is in process, the external device is given full control of the address lines as the drivers go high impedence.

1 2/6 8T97 provides a buffered I/O data output to as many as 7 Digital Group I/O boards (28 ports) without further buffering.

Data In to the CPU is placed on the Internal Bi-directional bus by 2 types of IC's. A pair of 74125's provides a TRI-STATE non-inversion buffering of memory data to the CPU. A pair of 7403's result in a pseudo tri-state inverting operation on I/O data being inputted from the Digital Group I/O board input ports. Notice that the pin connections and operation other than polarities for 74125's and 7403's are identical. If you should not use Digital Group boards for I/O, then use 74126's in place of the 7403's for data non-inversion with a positive I/O READ Strobe.

Memory on the CPU card is of two types, EROM and RAM. The EROM is a single IC preprogrammed by the Digital Group to simplify system operation. When power is applied to the system, a "power on reset" function results, which starts up the processor running at page 377 (FF). IC21 decodes the highest 256 bytes of memory, resulting in a ROM Chip Enable condition. The EROM proceeds through its programming to clear the screen, display a message, initialize some RAM addresses, and control initial cassette reading.

2K of RAM allows an extensive operating system to be entered from cassette. 16 2102's are arranged as 2 banks of 8 IC's. Which of the 2 banks is selected (if either) is a function of IC's 22, 23, and 24, as well as three jumper settings. The 7442 will assign the 2 banks of 2102's as the bottom 2K of 8 - 8K memory allocations.

The 3 jumpers permit assigning the CPU's 2K RAM to addresses other than the bottom 2K (addresses 000 000 - 007 377). When a user wishes to add one or more Digital Group 8K boards to his system, he may move the CPU's 2K to fall above the lastmost address of his highest supplemental 8K board. Example: A user has two Digital Group 8K memory boards on his system. By assigning the CPU's 2K to the address range of 16K - 18K, one memory board to 0K - 8K, and the other to 8K - 16K, an 18K system results.

Alternatively, the bottom 2K of memory on the 0K - 8K board could be omitted and the CPU jumpers arranged for 0K - 2K assignment. However, this example would be a 16K system.

The EROM is a relatively slow device, so the 6502 must be forced to wait for its data access. A 74121 provides a 1300 nanosecond delaying pulse to the CPU when either the CPU EROM is accessed or an external slow memory access is required. Since the Digital Group RAM's are 500 nanosecond access time or faster static RAM's, the CPU normally runs at full speed. The 6800 does not require any wait state, so the 74121 is omitted.

Construction

Tools: Very fine tipped, low-wattage soldering iron, "wire solder" (around 20 guage resin solder), small diagonal cutters.

Test Equipment: Ohmeter
Voltmeter (Digital preferred)
20MHz or better triggered sweep oscilloscope
Front panel in case of trouble

Estimated Construction Time: 5 - 15 hours

Warning: The CPU card represents the heart of a computer! Expensive components are used and troubleshooting can be a very challenging operation. A rushed, sloppy job will most likely repay the constructor with long and continuing hours of frustration with very misleading symptoms.

The majority of prototype and field test CPU boards worked the first time they were plugged in. Almost every initial failure has been traced to carelessness.

1. Insert the 40-pin and 24-pin sockets and solder. If the sockets have a keyway indication, orient this away from the connector (see component layout). Note - the top side of the board is indicated by the Digital Group label.

2. Insert and solder the 14 and 16 pin sockets. Be careful not to confuse a 16-pin socket position for a 14-pin. A special plating process was specified by the Digital Group to minimize solder joint troubles and discourage solder bridges. We would suggest a "warmup area" by starting with IC's above the crystal which have more open lines.

3. Insert and solder the 47 ohm 1/2 watt resistor and the 9V zener diode beneath the 24-pin socket. Note orientation of the zener's bar end towards the right. Space the zener's leads away from the top side of the board to prevent shorting the leads under the zener, and allow better heat disapation.

4. Insert and solder the 50 pfd, 100 pfd, and 220 pfd (6800) or 100 pfd (6502) capacitors. Be careful of leads running under the capacitor's bodies.

5. Insert and solder the 22 mfd capacitors. Note that the + polarity indication is towards the right. Avoid shorting any underlying lines.

6. Insert the 4.7K resistor.
Insert the three 220 ohm resistors.
Insert the four 470 ohm resistors.
Insert the two 2.2 Meg resistors.
Insert the 22K resistor.
Insert the four 2.2K resistors.
Insert the 2 100K resistors.
Insert 2 47 ohm 1/2 watt r's.
Insert 2 22 ohm resistors.
Insert the 15K ohm resistor,

6. (cont'd)

Insert three silicon diodes. Note the bar is towards the right. Space leads up to avoid shorting leads underneath.

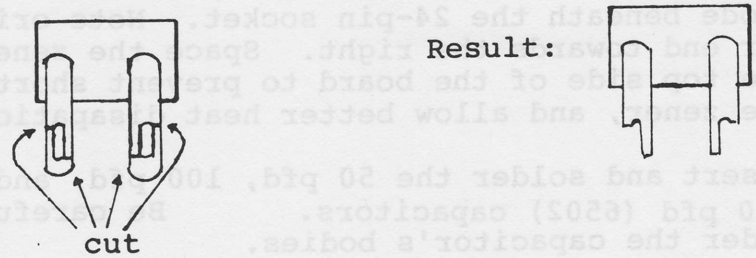
Invert board and solder above parts. Be careful not to miss any leads.

7. Insert and solder the .01 mfd capacitor above the diode in the lower right corner of the board. Insert and solder the three .01 mfd capacitors to the right of the 4013 (IC45). An additional problem is experienced on 6800's which seem to require bypassing of the Reset line (pin 40 of IC34.) This is most easily accomplished by connecting a .01 disc capacitor between the ground bus and the Reset line's feedthrough between IC's 36 and 44. The ground line can be found by looking for 0 ohms between the bus line and Connector pin 2. The Reset line may be traced and measured from pin 2 of IC 45 (4013).

8. A large number of holes for noise suppressing bypasses have been provided, not all of which are necessary. Large memory systems (over 16K) are more noise sensitive than small systems, and require more bypassing. Insert and solder .01's as shown. Be careful not to mistake a plated-through feed-through hole (smaller) for a bypass hole. One side of every bypass is connected to the ground bus (pin 2) if in doubt. Insert and solder the four tantalum bypass capacitors. Note that the positive (+) end of the dipped tantalum capacitors is indicated by either a vertical marking (paint stripe) along one side, or a plus sign.

9. Trim the crystal socket's pins as shown to fit into the crystal holes.

Pin view: Result:



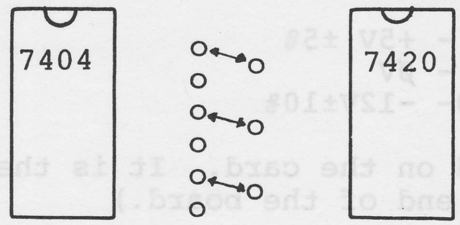
Press the rear tab into the board hole provided for it. Solder the pins and the rear tab.

The socket provides a space-saving flat mount as well as avoids soldering to the heat-sensitive crystal.

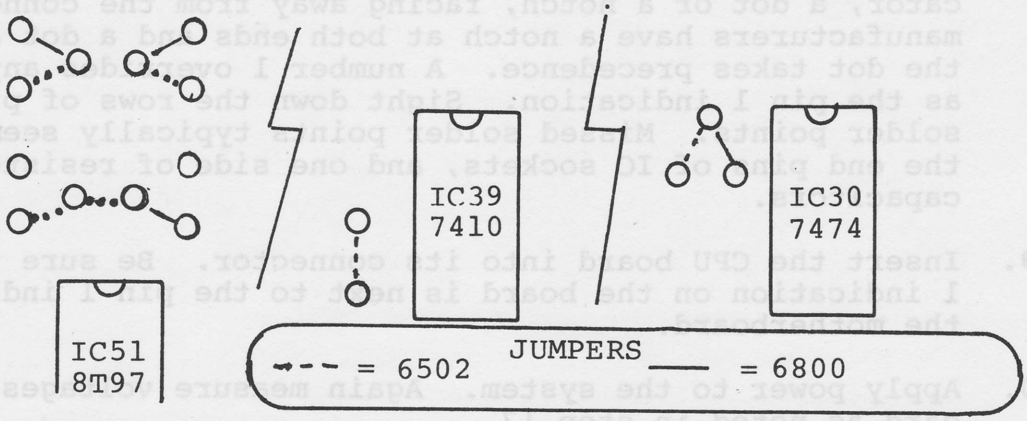
10. Insert and solder the two 8-pin flat resistor packs. Note that the end with the dot (common pin end) is oriented away from the connector.

11. Plug in the three 16-pin resistor packs. Note that the orientation of the dot or keyway is <u>away</u> from the connector. This places the common lead of the R-pack on the #16 pin lead to +5.

12. Form three jumpers from resistor tails or similar wire. Insert to jumper as the lower 2K of the lowest 8K. This permits initial testing without a supplemental memory. The jumpers' orientation should be:



Connect the other 5 jumpers for 6800 operation or 6502 operation (6 jumpers) as shown below.



13. OK, now for a little ohmeter testing. Check for a short between pins 1&2; 2&50; and 1&50. 1&2 should measure a high or ∞ resistance. 2&50 will show some resistance due to the zener, and ohmeter polarity, but not a short.

14. Two techniques are possible at this point. One way (referred to in fine literature as the "smoke test") is to plug in all IC's and insert card. Another way is to insert only one or two IC's - function by function - and test as you go. The Digital Group has found a compromise seems to work best, namely, to plug in all but most critical and/or expensive IC's, then test. Then if ok so far, plug them in and go ahead.

15. Insert all IC's except 6502 or 6800, 1702A, and 2102's. Note that all IC's except 2102's have their keyway or dot indicating the pin 1 end oriented away from the connector. Do <u>not</u> insert IC's 37 and 35 if using a 6502 CPU! Do <u>not</u> insert the 74121 (IC25) if using a 6800.

16. Measure the resistance at the pins mentioned in step 7 again. In particular, note the lower resistance value between pins 1&2. Reverse the ohmeter and remeasure. A shorted reading indicates a bad IC, and near equal readings indicate a reversed IC. Insert the crystal into the holder by <u>gently</u> snapping in the body of the crystal, then pushing forward to contact the pins.

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17. Before inserting the CPU card into its connector, measure the voltages at the connector. A single wrong voltage may cost you a CPU board worth of IC's.

Measure against ground:

Pin 1 - +5V ±5%
Pin 2 - ØV
Pin 50- -12V±10%

(Pin 1 end is marked on the card. It is the connector pin nearest the memory end of the board.)

18. Make a final inspection of the board. Check for shorts between components on the top and lines running underneath, and solder bridges. IC's and R-packs should be inserted with pin 1 indicator, a dot or a notch, facing away from the connector. Some manufacturers have a notch at both ends and a dot at one end - the dot takes precedence. A number 1 overrides any other mark as the pin 1 indication. Sight down the rows of pins for missing solder points. Missed solder points typically seem to occur at the end pins of IC sockets, and one side of resistors or capacitors.

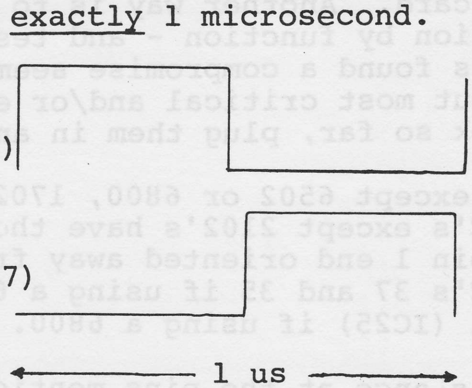
19. Insert the CPU board into its connector. Be sure that the pin 1 indication on the board is next to the pin 1 indication on the motherboard.

20. Apply power to the system. Again measure voltages at the CPU card as noted in step 17.

21. If using a 6800, connect a calibrated triggered dual sweep oscilloscope to pins 3 & 37 of the CPU socket. Set the triggering to occur on the + rise time, and the sweep setting to 100 ns/div. Look for a cycle time of 1 microsecond as shown below. If your oscilloscope does not sweep as fast as 100 ns/div, then a slower sweep can be used, but be absolutely sure that the cycle time is <u>exactly</u> 1 microsecond.

Phase 1
(IC34 pin 3)

Phase 2
(IC34 pin 37)



1 us

A frequency counter may also be attached to pin 6 of IC52. The desired frequency is 1.0 MHz. Any appreciable error indicates a defective crystal or a bad IC52.

22. Apply Power briefly to avoid excessive dissipation of the zener.
Measure the voltage at the following pins. Correct any discrepancy.

6502/6800	(IC34):	pin 1 - ØV
		pin 8 - +5V
1702A	(IC20):	pins 24 & 16 - -10V
		pins 12, 13, 15, 22, &23- +5V
Any 2102 RAM:		pin 9 - ØV
		pin 10 - +5V

23. Remove the CPU card. Plug in the TV readout board. Connect a monitor, and place a temporary jumper to ground on pin 1 of the TV Readout board. A random assortment of characters should be displayed on the monitor when power is turned on. Remove power from the TV Readout and then remove the temporary jumper.

24. Insert the I/O board. Be sure that the I/O board address jumpers are connected so that the Ports Ø, 1, 2, and 3 are being accessed.

25. Carefully insert the 6502 or 6800, 1702A, and the 2102's. Note that pin 1 is indicated by either a dot or a "1" on these IC's, and should be oriented away from the connector. The 2102's are mounted horizontally, so the dots (sometimes notches) are oriented towards the left edge of the board (away from the connector). Recheck the board for orientation, lead shorts, solder shorts, and missing solder joints.

26. Think courageous thoughts. Plug in the CPU board. Bravely turn on power. If things are working, a message will appear on the screen.

27. The message should begin at the top leftmost edge of the screen and say, "Read 6502 INITIALIZE Cassette" or "Read 6800 INITIALIZE Cassette" as appropriate. This message checks out the major portion of the Digital Group Microprocessor Systems. Pressing the "Reset/Start" switch should cause the screen to flash and redraw the message.

28. Insert the 6502 INITIALIZE cassette (or 6800 INITIALIZE) into the cassette recorder. Start the first recorded data burst. When the tone begins, press the "Reset/Start" switch momentarily. When the data begins, the screen should progressively display 256 "Ø's", 256 "1's" . . . up through 256 "7's" as data is read. The displayed numbers indicate the page of the current data byte being read. After the INITIALIZE cassette has been read, the screen should display the selections of the Operations Monitor.

29. Press "3" on your ASCII keyboard attached to Input Port Ø. The screen should display the contents of the internal accumulators, etc. Press "Space" and you should page through memory.

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30. Try the other Operations Monitor routines described in the included software description.

32. This completes the major testing of the Digital Group 6502 or 6800 CPU card. Further testing involves connecting supplemental Digital Group 8K memory boards and verifying proper operation, and running extensive test loops to find any heat sensitive components. Use of surplus parts has a tendency towards temperature failure should you have used surplus 2102's in an unpopulated memory board. Noise sensitivities may show up with various card arrangements, and the "Troubles" section may aid you in your troubleshooting.

SPECIAL NOTES:

EROM's

The 1702's used on the Digital Group 6502 and 6800 CPU boards are selected for fast access times. In addition, the -voltage applied to the EROM has been raised to -10 volts instead of the typical -9 volts. -10 volts on the EROM prevents a pattern sensitivity program runaway condition under severe heat and large memory system condition. After lowering the voltage to -10, no failures were noted in the more sensitive EROM's, even when the EROM was heated "too hot to touch." The exact voltage at pin 24 of IC20 should be measured after the system has been successfully completed and tested. The voltage should be -10 volts ±.5 volts, preferably very close to -10 volts. The measured voltage should not change more than .25 volts from the "Read 6XXX INITIALIZED Cassette" message to the Operating System Message display. Greater than .25 volts means that R1 (27 ohm, ½watt) should be slightly reduced in value.

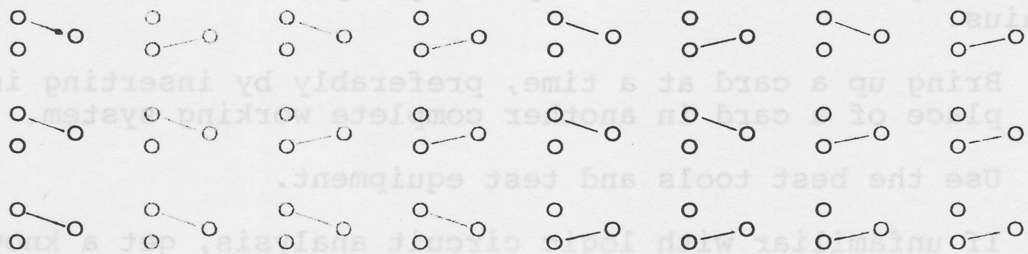
Power On Reset

Some early users noted that some systems did not result in the "Read 6XXX.." message upon simply powering up, but required the "Reset" button to be also pushed. This problem is caused by the chance state of the Type D flip flop IC38, pin 6. Pin 6 should be high to allow normal CPU Ready operations. Pressing the reset key forces a "Preset" to a high condition on IC38, pin 6. through D2. A future engineering change will cure the problem by replacing IC38 with a 74L74, and connecting the anode end of D2 to IC45, pin 2 instead of the present connection to Connector pin 47. A temporary fix is to swap IC38 (7474) with another 7474 (like IC30) until one is found which always powers on with IC38 pin 6 high. Another fix is to place one of the 1 mfd tantalum bypasses from IC38 pin 1 (+ end) to ground. This will produce a separate "Power-On Preset" pulse.

Using the CPU Board in a system

1. The Digital Group "6000 series" CPU board's 2K of RAM memory is initially set to the lowest 2K of the potential 64K in a system for testing. However, the three jumpers between IC22 and IC23 may be rearranged so that the 2K may be assigned to seven higher addresses in memory. This allows Digital Group 8K memory boards to be used with the system and the 2K of RAM on the CPU board to be assigned immediately above the lastmost address of the external RAM.

   The jumpers are:



0-2K 8-10K 16-18K 24-26K 32-34K 40-42K 48-50K 56-58K

   Example: You have an 8K board to use with your system. Connect the 8K memory to assign its 64 - 2102's to 0 - 8K. Select the above second jumper combination to assign the CPU's 2102's to 8 - 10K. Your system now has 10K for its 80 2102's. However, be aware that the supplemental 8K board must now be plugged in so that the system initialization at the lowest 2K may occur!

2. Noise problems can occur, particularly in large systems. Several fixes have been found successful.

   a. "Pin bars" on the ground and +5 lines on the mother board to lower the noise impedence.

   b. Tantalum bypasses at power supply regulators.

   c. Put 3K pullup resistors on the 8K memory boards' address lines.

   d. Even IC's on the I/O board can cause troubles. 74LS01's instead of 7401's were found to cause strange noise problems which disappeared when the original 7401's were used.

   e. Impedence matching the bus lines (See Computer Design Dec. '75 p. 97 for design concepts.)

3. A small, quiet blower is advisable in larger, enclosed systems. We would suggest mounting the blower near the CPU card and memories, on the CPU side of the cabinet. Have an exhaust vent on the opposite side for a steady cross current of ventilation.

Troubles

1. Troubleshooting a Microprocessor system can be an extremely challenging situation even for experienced electronics servicemen. Several general principles should be followed where possible. We want you to enjoy your system quickly, not religate it to a closet pending a potential stroke of genius.

    a. Bring up a card at a time, preferably by inserting in place of a card in another complete working system.

    b. Use the best tools and test equipment.

    c. If unfamiliar with logic circuit analysis, get a knowledgable friend to help you.

    d. Attack the obvious problems first. Often very misleading "major" troubles are caused by a "trivial, easy to get later" trouble.

    e. Keep exact records of the troubles, symptoms, and cures. Send us a copy so that we can help others.

    f. If you and others are hopelessly baffled by your CPU card, try "Easter Egging" - replace the IC's which might even remotely affect the problem.

    g. If all else fails, take advantage of our repair policy.

2. Perhaps 90% of the troubles are fixed by one or more of the following problems (listed in order of probability of occurance):

    a. IC or R-Pack inverted in socket.

    b. Missing solder joint - generally on the end pins of an IC socket or one side of a resistor or capacitor.

    c. IC pin folded under an IC rather than inserted into socket.

    d. Solder bridge, "splash", or a PC board drilling burr.

    e. Wrong IC or Resistor in a given location - Confusing a plated-through hole (smaller) for a component pad.

f. You reassigned the bottom 2K of RAM to a supplemental 8K board, but don't have it plugged in.

g. The jumpers are misplaced or missing (8 jumpers total for 6800; 9 for 6502).

h. Two clock IC's omitted for 6502 are inserted; or missing if using 6800.

i. Extraneous characters: wrong IC44 and/or IC52.

3. 9% of the problems are caused by the following:

a. Defective crystal oscillator. The Digital Group spent two weeks on one board to discover the value of step 21 of the construction guide.

b. Misc. defective or mismarked components. In case of totally illogical troubles, don't assume component marked values truthfully represent what lies inside.

c. Defective sockets making intermittant connection. Tap and flex the board while running. Measure IC's only from the top side of the board. Memory IC's are very misleading since an unconnected address pin will result in multiple addressing of the same location.

d. A very slow access 1702A.

e. Noise. Extremely difficult to trace, but generally only shows up on large memory systems.

4. The remaining 1% are the truly difficult ones, and require imagination, inspiration, and luck. Maybe prayer too. We want to compile a list of troubles found as a guide to future builders, and would like to hear about your strange troubles - causes and cures.

5. The troubled CPU card may be carefully analysed for apparent problems, but eventually must be carefully diagnosed to get the difficult ones. The single step operation generally finds the problem quickly.

6. Use the following procedure when attempting the single step analysis for 6502.

a. Disconnect the "Run" jumper between +5 and CPU pin 43 (if connected).

b. Install a "Run" and "Stop/Step" normally open push switch. Use a good quality, low bounce switch for "Stop/Step". Connect to CPU pins 43 & 44 as shown in the schematic.

c. Measure the pulse at IC46 (74123) pin 5. It should be ≈50 ms long single pulse for each "Stop/Step" depression.

d. Next, look at IC38 (1/2 7474) pin 8. Again a single pulse high for each depression should be seen. The pulse will be very short.

e. Build the emergency front panel (or borrow from a friend).

f. Insert the card and turn on the system. Press "Stop/Step" and then the "Reset/Start" switch.

g. Step through the appropriate chart provided. Carefully note the slightest discrepancy.

7. Once the single step operation operates successfully, try the "Run" to see if the message will appear now.

8. Once the Start-up routine works, retry loading the cassette.

Specific Troubles

1. Shorted address lines on CPU card.

   Shows up on single step as non-addressable memory positions.

2. Strange memory jumps.

   a. Resulted from a defective 74125 which was not passing back the right memory data.

   b. Another resulted from a defective 74121 single shot not delaying the CPU when addressing ROM.

   c. Very slow 1702A. All 1702A's preprogrammed by the Digital Group are pretested.

   d. Defective 2102 in memory, returning a bad address (particularly the leftmost column when singlestepping.)

3. No single step.

   a. Reversed diode leading from the step switch.

   b. Missed jumper in the upper left corner.

4. Single steps ok, but no tv operation.

   a. I/O board not properly decoding to port Ø.

   b. Defective 74100 on I/O board.

   c. Defective line on motherboard.

5. Cassette won't read.

   a. Defective 7403.

   b. Maladjusted Cassette Interface on TV board.

6. Cassette loads data but won't end in Operations Monitor Display.

   a. Bad 2102 in Memory (generally in the IC10 - IC17 column).

   b. Defective cassette - noisy, dropouts, poor recorder used.

   c. Worn or misaligned heads on cassette recorder.

   d. Recorder volume too low.

   e. Recorder used to read the cassette is running at the wrong speed.

   f. Shorted memory address lines.

7. CPU card won't work with 8K board in.

   a. Shorted address lines on 8K board.

   b. - - Won't work at certain addresses - shorted data to address lines.

6502/6800 CPU Parts List

Qty	IC's
1	6502 or 6800
1	1702A, programmed as 6502 or 68A
16	2102-1
1	7400 (6800 only)
6	8T97
1	74L00 (6502 only)
1	74LS00 (6800 only)
1	7402
2	7403
1	7404
2	74L04
2	7407
1	7410
1	7420
2	7430
2	7442
2	7474
1	7493
1	74121 (6502 only)
1	74123
2	74125
1	4013
1	75451 (6800 only)

Diodes

1	10 volt 1 W Zener 5% - 1N4740A
3	1N4148

Resistor Packs

3	16-pin 2.2K dip
2	8-pin 2.2K sip

Capacitors

1	50 pfd mica
2	100 pfd mica (1 for 6800)
1	220 pfd mica (6800 only
21	.01 mfd discs (20 for 6502)
5	1 mfd tantalums
2	22 mfd tantalum - 1" centers

Qty	Resistors
2	22 ohm 1/4 W
1	27 ohm 1/2 W
2	47 ohm 1/2 W
3	220 ohm 1/4 W
4	470 "
4	2.2K "
1	4.7K "
1	15K "
1	22K "
2	100K "
2	2.2Meg "

Sockets

1	8-pin
21	14-pin
29	16-pin
1	24-pin
1	40-pin

Miscellaneous

1	1.0 MHz crystal
1	Crystal socket
1	PC Board
1	50-pin dual connector
1	System Distribution Cassette (6502 or 6800)

Documentation

1	"Digital Group Systems"
1	"Digital Group 6502/ 6800 CPU Card"
1	"6502" or "6800" Operating System"
1	"MOS Technology Programming Manual" (6502 systems only)

Single Step Testing of a 6502 CPU Card

1. Power on while holding down the Halt/Single Step key.
2. Press Start/Reset switch.
3. Stepping should display: ((XXX) = Data varies)
   (Number of steps until initial valid data may vary slightly.)

6502 Address	6502 Data	6502 Comments
XXX	XXX	
XXX	XXX	
377001	370	
377002	242	
377004	232	
377005	245	
000000	XXX	
377010	123	
377013	305	
001377	XXX	
377263	040	
001375	XXX	
377324	376	
377326	000	-Screen blanks if
377331	376	not already blank.
377333	322	-Screen reappears
377270	205	with ■ in lower
377272	251	right corner.
377274	205	
377276	040	
001375	377	-Critical RAM
001373	XXX	address (IC00-07)
377322	215	
377324	376	
377326	000	-Screen blanks
377331	376	
377333	322	-Screen reappears,
000025	000	upperleftmost
377315	371	character is blank.
001373	377	
377322	215	-Program is looping,
377324	376	clearing the screen.

4. Press Run. Message should appear on the screen. Numbers running indicates a "Ø" cassette output (or a bad Port 1 or I/O line into CPU 7403's). Press Halt/Single Step. Each subsequent depression should step around the loop. The initial address may be anywhere in the loop.

6502:	377103	376
	377105	001
	377110	242

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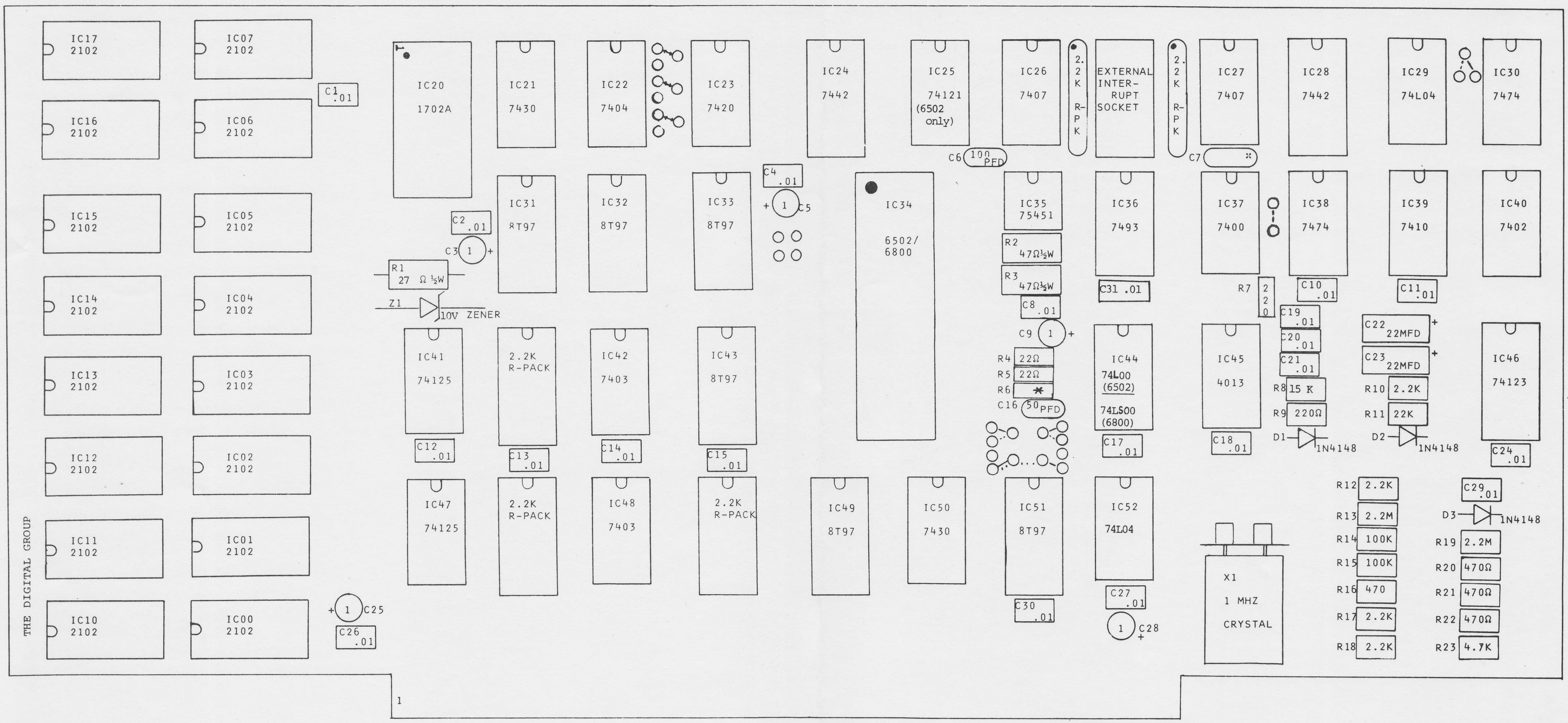
DIGITAL GROUP SYSTEMS   6502/6800 CPU CARD - COMPONENT LAYOUT



*	6502	6800
C31	not used	.01
C7	= 100 PFD	220 pfd
R6	= 22C	1K

NOTE: JUMPER CODES

ARROW JUMPER = RAM ASSIGNMENT (BOTTOM 2K SHOWN)
DOTTED JUMPER = 6502
SOLID JUMPER = 6800

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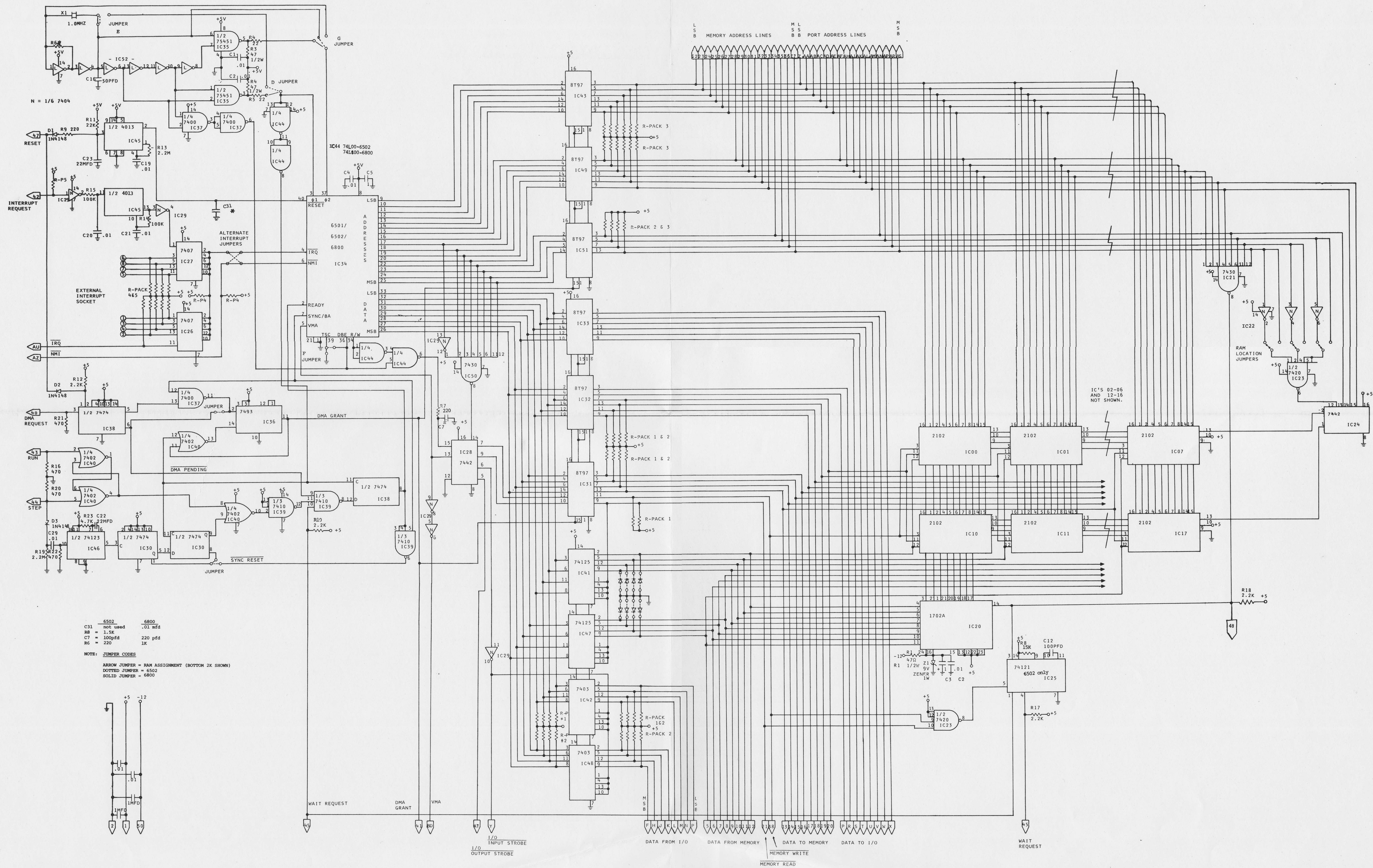

	6502	6800
C31	not used	.01 mfd
R8 =	1.5K	
C7 =	100pfd	220 pfd
R6 =	220	1K

NOTE: JUMPER CODES

ARROW JUMPER = RAM ASSIGNMENT (BOTTOM 2K SHOWN)
DOTTED JUMPER = 6502
SOLID JUMPER = 6800