DURDA

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TRS-80 Technical Manual Troubleshooting

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INTRODUCTION

This manual will give you, the service technician, the technique necessary to troubleshoot and repair the TRS-80 Microcomputer System. It is designed to give you the basic Section isolation knowledge necessary to get you into the proper Section of the schematic and to root out the failed components. What this manual cannot do is grab you by the ear and apply your nose to the bad part! Some manuals try to do just that by supplying page after page of symptom/cause/effect tables. That type of troubleshooting will work fine on products that are serial in nature; in other words, "the input signal is here; goes through this and that and comes out over there." In a microprocessor-based computer a parallel bus structure is used. An input to one Section could be working fine, but the output is garbled. This output can screw up another Section and make you believe the second Section is bad. To make matters worse, you cannot really be sure what effect the bad Section has on the other Sections. In a parallel system, cause/effect tables are useless because any Section could cause problems that have the same symptoms.

In a parallel structured system, Section Isolation is the most difficult. Only one line may be defective, but finding that one signal could be time consuming if not impossible unless you know where to look. In some cases, the problem will be so obvious that it screams at you; and you'll see it as soon as the plastic cover is off. In others, the bad component or signal may be so deeply buried that only a step-by-step elimination process technique can be used to root out the problem.

One of the best tools for troubleshooting is system knowledge. Know the TRS-80. Have you read the theory of operation section? Do you understand it? Do you need to read it again? If you're not sure how a Section works, look it up in the theory section. Maybe that signal you suspect should look like a short most of the time. The manual will give you that knowledge.

Another time-saver is the customer. If possible, get the whole story from him about the problem. Of course, he or she would not be able to supply such info as "I've got a bad RAM"; but, you might find the problem only shows up during one or two system commands. In some cases, a short talk with the customer can correct a problem without even opening the case. Maybe he or she has made some kind of software error. A short demonstration on the suspect computer or another in-house system can eliminate that problem entirely. The most basic step in troubleshooting is duplication of the problem. If possible, the customer should be present to show you the condition of failure. You may not be able to confirm that a problem exists unless you have communication with the customer. You are a Service Center — give expert service!

DISASSEMBLY

To disassemble the TRS-80, perform the following steps (see Figure 1):

1. Position the computer with the key caps down. Use a padded surface; the key caps are easily scratched.

2. Remove the six screws from the bottom of the case. Notice the three different screw lengths and set them aside in pairs.

3. Set the computer on its feet in operating position and carefully separate the top of the case from the bottom.

   NOTE

   LED mounting differences: There are two types of LED mounting positions. A double-sided, plated hole keyboard PCB uses an LED mounted into the top half of the case through the use of a socket and a retainer ring. Long wires interconnect the keyboard PCB and the LED. Slip the ring off the socket body using needle-nose pliers. Allow the ring to slide down to the keyboard PCB. Use an eraser-tipped pencil to push the LED down through the plastic case from the top. You can then remove the LED from underneath the case. Bend the LED leads slightly to prevent the retainer ring from getting lost.

   The second mounting technique has the LED soldered directly to a single sided keyboard PCB. No retainer ring is used because the LED is not held by the top of the case. The top half of the case simply fits over the keyboard and the LED.

4. Set the top of the case aside. Lift the keyboard off of the plastic bosses. **Avoid putting undue strain on the interconnect cable at the lower left corner of the case.**

5. Notice the five rubber spacers between the keyboard PCB and the CPU Board. Make a note of which plastic bosses the spacers are on, then remove the spacers.

6. Carefully lift the CPU Board out of the main case while holding both Boards. **Do not put undue strain on the interconnect cable!**

7. Set the bottom case aside and lay the two Boards on the working surface, solder side down. Orient the Boards such that the keyboard is closest to you. The keyboard will appear to be upside down, but the CPU Board will be properly oriented for troubleshooting. Most problems will be associated with the CPU Board.

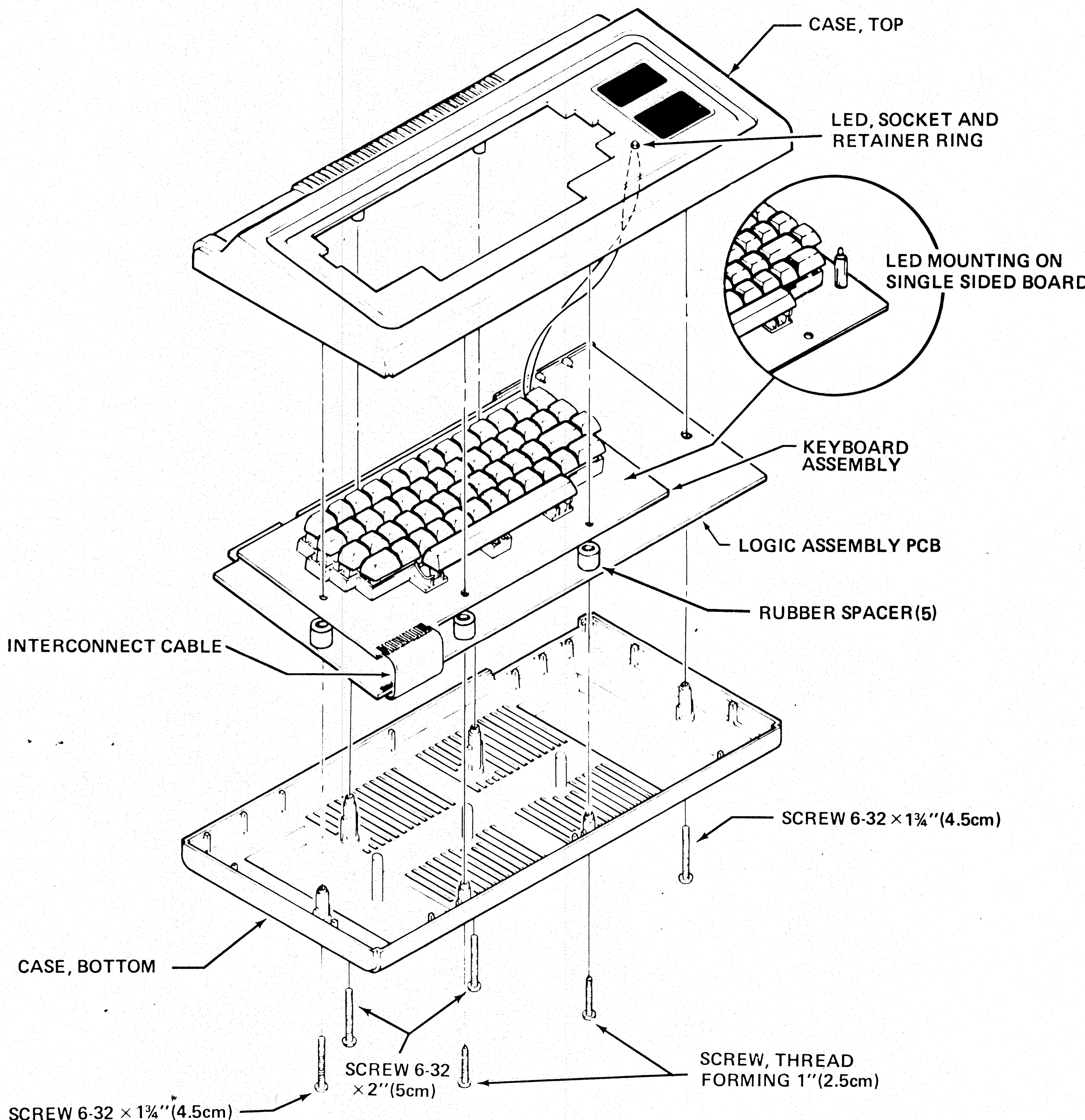

FIGURE 1. EXPLODED VIEW.

POWER SUPPLY CHECKS AND ADJUSTMENTS

Once the unit has been removed from the plastic case and the Boards are resting on the test bench, connect the power and video DIN plugs.

CAUTION

The CPU Board is now "upside down" in reference to its normal position in the case. Be sure you insert the power DIN plug in the power jack, J1 and not in the Cassette jack, J3. The power jack is the one closest to the power switch.

Turn on power to the CPU Board and the Display. Data may or may not be present on the Display depending on the type of problem. Disregard the Display for the time being. Test power supply voltages first (see Figure 2).

1. Attach a digital voltmeter, or equivalent, with the common (–) lead to the right side of capacitor, C9 – that's the largest capacitor on the Board.

2. **12 VOLT SUPPLY.** Select the +20 volt DC scale on the meter and touch the red (+) lead to the top side of the power resistor, R18. (The "top side" would be the end closest to the edge of the PCB). Voltage should read 12.0 volts ±5% (12.6 to 11.4 volts). If the voltage does not fall within these limits, adjust R10 for a correct reading.

3. **+5 VOLT SUPPLY.** Select the +10 volt DC scale on the meter and touch the red (+) lead to the left side of R4. (This 1 watt resistor is located between the two large electrolytic capacitors, C8 and C9). Voltage should read 5.0 volts ±5% (5.25 to 4.75 volts). If the voltage does not fall within these limits, adjust R5 for a correct reading.

NOTE

Do not attempt a 5 volt supply adjustment unless the 12 volt supply has been checked and is within tolerance.

4. Select the –10 volt DC scale on the meter and touch the red (+) lead to the anode side of CR2 (CR2 is located to the left of the power switch). Voltage should read –5 volts ±5%. There is no adjustment for the –5 volt power supply. If this supply fails to fall within the voltage range, you must isolate the problem to a defective component(s).

SECTION ISOLATION

Usually, customer complaints are directed to a certain function. For example: "It CLOAD's fine, but when I list the program, half of the listing gives me a screen full of junk." Since part of the listing is correct, we can assume the audio processing circuitry works. You would suspect – 1, a problem with tape data or – 2, a RAM error is screwing up the data input. You might listen to the tape's audio for voids, or attempt to load in SCQATS and exercise the RAM's. In either case, the customer's feedback has given you clues as to where to look for a problem. It would then be up to you to eliminate the suspected areas down to a bad component.

One of the hardest complaints to Section Isolate is this: "Everytime I turn it on, I get a screen full of junk – ". A screen full of junk is defined as a display with all character positions filled with either alphanumerics or graphics. The factory's name for this condition is, "a screen of garbage".

As you read in the theory of operation section, at power-on the CPU exercises an initiation procedure. A garbage condition results from the CPU bypassing this routine as it goes crashing through any other routine it finds. Unfortunately, a garbage condition does not always indicate that the power up logic is defective. A problem could exist in RAM, ROM, the video divider chain and, of course, the CPU itself. Therefore, a problem could exist in 75% of the computer. Where do you start? You could start replacing everything that's easy to get out: RAM, ROM and the CPU. But, you are really wasting time. If the problem is a simple solder short, replacing all socketed devices is not going to help. There is a method you can use for Section Isolation, it is based on a removal technique that eliminates sections from the suspect list.

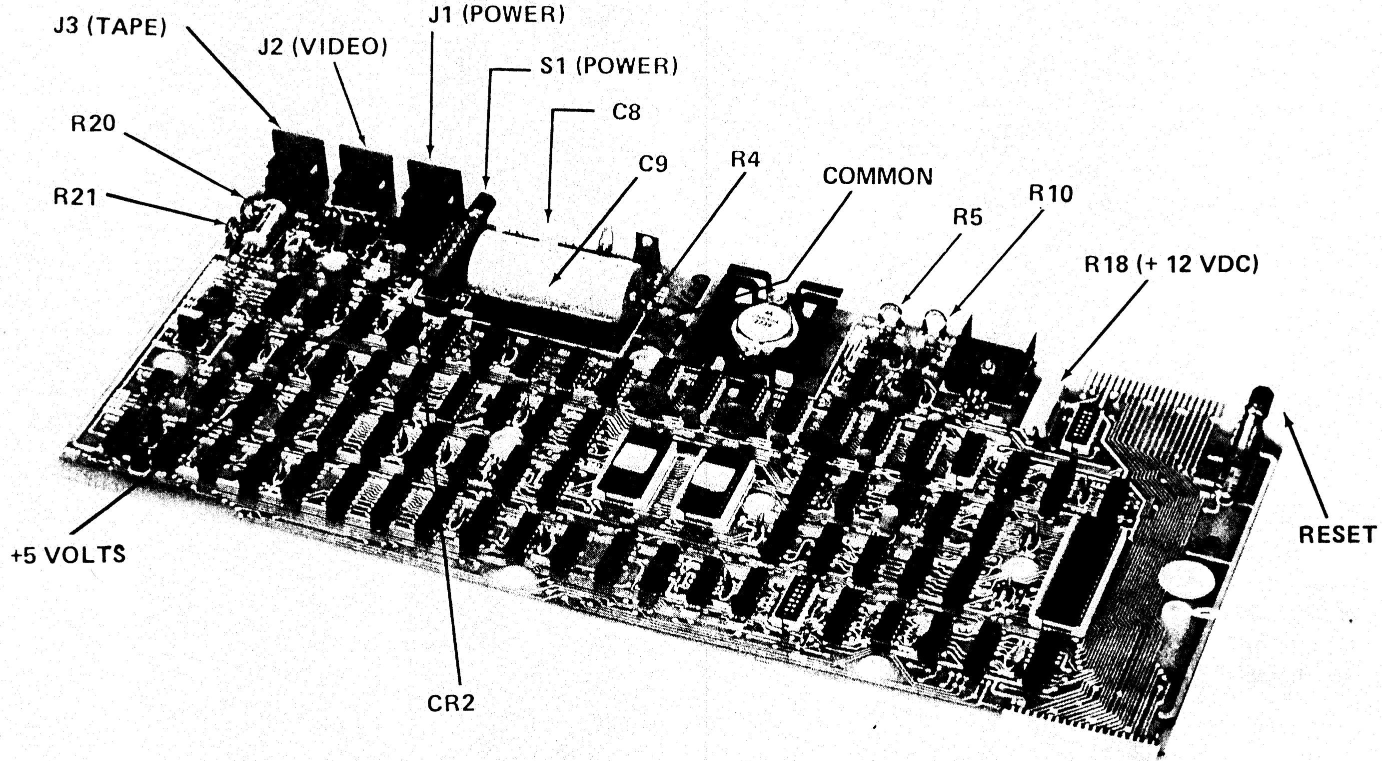

FIGURE 2. LOGIC BOARD.

SECTION ISOLATION FLOWCHART

A flow chart of Section Isolation by part removal is shown in Figure 3. You start the process in the parallelogram, block 1. This block is where you duplicate the customer's problem. Block 2 instructs you to disassemble the unit and reconnect the video and power inputs. Block 3 is a decision block. Do you have garbage on the screen now? If so, you continue to block 5. If not, block 4 tells you to suspect a shorting interconnect cable between the keyboard and the CPU Board. You could also have loosened a "solder ball" during disassembly, and a short is now gone. Examine the interconnect cable carefully for shorting conductors. Did anything fall out of the computer during disassembly? You might have fixed the computer just by taking it apart! Test it again.

At block 5, you will turn off power to the unit, wait about ten seconds, then reapply power. The delay gives the initialization logic time to reset. If there is now a "Ready" on the screen at block 6, maybe you have a problem around S2 or C42, as block 7 instructs.

In block 8, you are instructed to remove the DIP shunt (X71) at Z71. With X71 removed, the RAM's are not electronically in the system. When power is applied, the ROM and the CPU are in communication, but there is no data flow to or from RAM. The screen should show a pattern of 16 character lines of 32 colons. If the CPU shows large colons, you could have RAM problems or keyboard type problems. Blocks 11 through 15 will help in isolating that type of problem. As blocks 12 and 14 imply, there are two colon displays. One display is stable. The other is blinking and flickering as the CPU constantly interrupts video addressing. Depending on the status of the keyboard, you could have data line or keyboard problems.

The next step at block 16 is to remove the ROM's. The CPU is now locked up without instruction from ROM. The pattern to look for is a screen full of @9's. The display should be in 64 character format at this time. The display will flicker as VID* continually accesses the video ROM's.

If you get @9's on the screen, you probably have a ROM error. If no @9's or partial @9's are visible, you could have video chain or video RAM problems. If you still get garbage, maybe the CPU is dead or something is making the CPU not function.

As you can see, the part removal isolation technique uses a lot of maybe's, question marks and could be's. The "what if's" are trying to tell you that, "I don't work all the time". You could have ROM problems and yet get large colons. You could get @9's and still have CPU error. But it's better than nothing, and the process does give a starting place.

ACTIVITY, STEADY STATE, FLOATING

Normal troubleshooting techniques call for an output to input sweep of the bad signal line. In other words, once a bad signal is found, the circuit is traced backwards until the signal is correct. The failed device will be located between the good input and the bad output. We will use this backward approach to isolate the defective components in the TRS-80. But, we will not attempt to analyze inputs and outputs unless we are between that magical good-in/bad-out point. What we'll do most of the time is check for activity or status of signal levels. If it has no activity or status, it must be floating.

Activity is defined as any logical transistion from high to low or vice versa. For example, the output of oscillator buffer Z42, pin 6, always has activity. There is a constant output pulse train at this pin. The signal swings from almost ground to over 3 volts continuously.

Steady state is defined as a logical 1 or logical 0. For example, Z40, pin 16, has a steady state logical 1. It is held high by resistor R50. Another example is the logical 0 at pins 6 and 7 of Z56, the CPU clock divider. Z42, pin 8, is always low unless resistor R67 is grounded.

Floating is defined as a signal level between the steady state of a logical 0 and a logical 1. The CPU, the ROM's, the RAM's and the data and address buffers are all tri-stable devices. When tri-state type parts are disabled or unselected, the output may show a floating condition. In a floating condition, the output will show system noise flickering through it. The average level of the noise will attain a voltage of 1.5 volts or so. TTL devices define a logical 0 to be equal to, or less than, 0.8 volts. A logical 1 is defined as a voltage level equal to, or greater than, 2.4 volts. Any voltage between these two levels will be considered floating.

A floating signal may be "finger tested". If a finger is placed on a floating signal, the amplitude of the signal will increase radically. The noise floor is said to increase. An example of noise floor is readily seen: If a ROM is disabled, the data output pins will be floating. The noise floor will show an average of 1.5 volts or more. If a data output pin is disconnected from the socket then checked, it may have no noise floor and may look like a logical low. A quick finger test of the pin will cause the noise floor to increase rapidly. In both cases, the pin was floating. But, when the pins were disconnected from the socket, the ROM lost it's noise source and looked low. The finger supplied a new noise source.

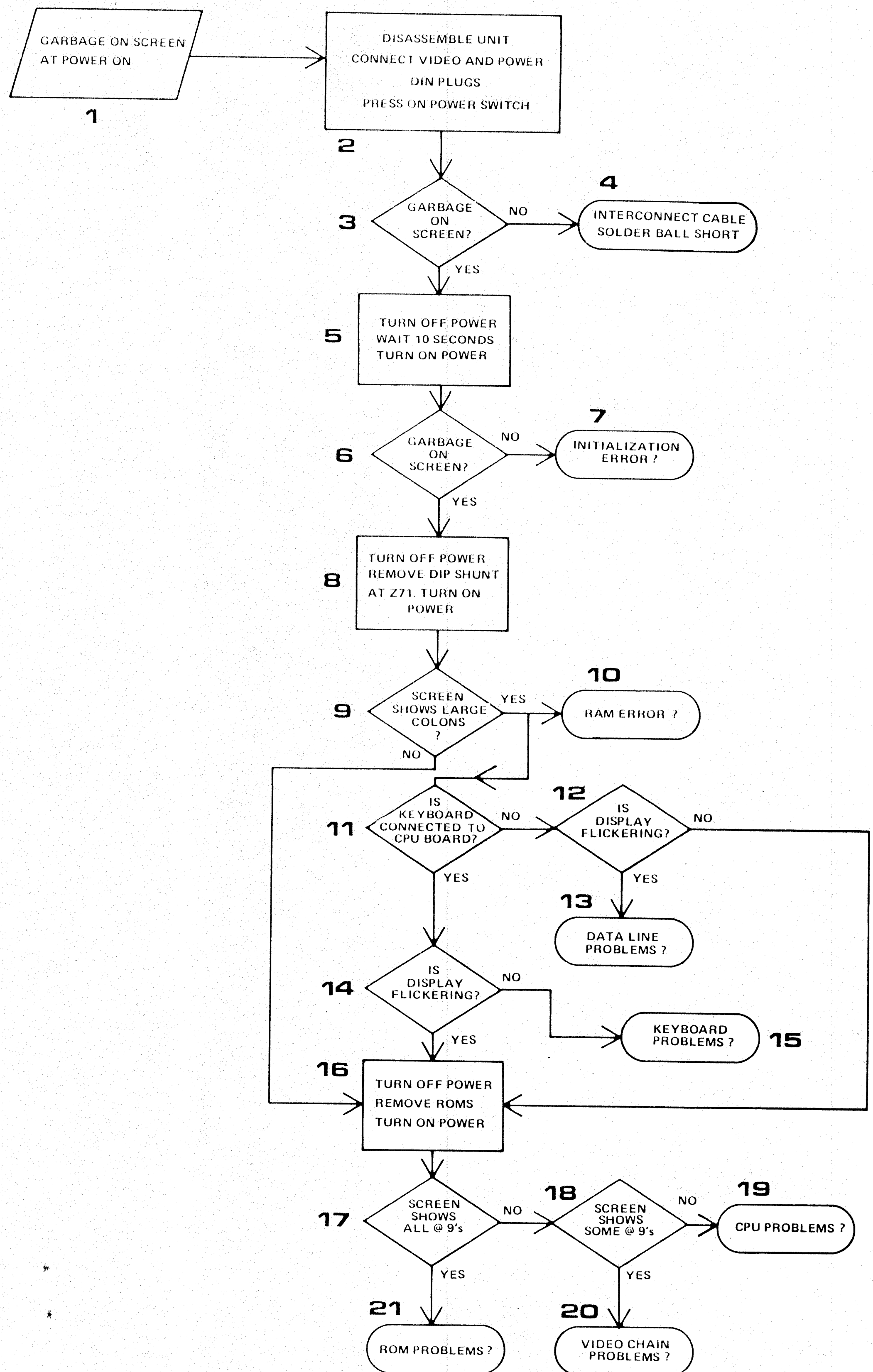

FIGURE 3. PART REMOVAL, SECTION ISOLATION.

CPU

Problems with the CPU does not mean that Z40 is inoperative. It could mean that you have difficulty with the address and data buffers, the control group, CAS/RAS timing, or with one of the CPU's support devices. Since you think that you have a problem with one of these devices, you might substitute a known good CPU for Z40 for a quick check. But, chances are that the problem exists in another place. Do not believe that Z40 is trouble-prone just because it's in a socket and is easily replaced.

The flowchart, shown in Figure 4, will help in CPU troubleshooting. The primary objective of this chart is to allow you to quickly find a signal that should be active but isn't. The main flow of the chart is on the left side of the Figure. Here, you are checking for activity on address and data lines. Without activity on the address lines, you are immediately branched off to the CPU's support group to find out why. Pay particular attention to the appearance of address line outputs. Any tri-state looking signal could mean a potential short between address lines. The opposite is true of data lines. These signals may be active and have floating components between active states. Hence, data line shorts are extremely difficult to find, using an oscilloscope.

If you need to disable the CPU for short checks, ground pin 25 of Z40 (or the side of R58, whichever is easier). The address lines will float on the CPU side, and the address buffer will be tri-stated. On the data lines, the output data buffers will be disabled, but the input buffers to the CPU will be enabled. Since the inputs to these buffers should be floating, the outputs will all appear high. You can check for a high at each output. If you want to see if the buffer operates, inject a TTL signal into the floating input and look on the output for that signal. You have a lot of signal sources in the video divider chain to choose from. You should see the activity of your injected signal without any floating components. If an output appears to have a floating condition, look for CPU-side shorts with other data bus outputs.

ROM

Problems associated with the ROM's can be broken down into three areas. You can have addressing, data or chip select problems. Addressing problems can be associated with open or shorted address lines going to the ROM sockets. Earlier Board levels may have jumper modifications on the solder side of the Board that have broken loose. There is also the chance that a ROM was partially knocked out of its socket during shipping. The address lines should be checked at the chip. Normally, there will be activity on all lines. You can also use the TEST* signal in the CPU section to disable the address lines and look for shorts on the address bus.

There are two types of data problems. The first is the non-repairable bit error internal to the ROM. The checksum contained in the SCQATS program can readily verify this. If the ROM problem is too severe for SCQATS loading, a replacement test may be necessary. The second type of data problem is the short or open on the data output. If you remove DIP shunt Z3, the ROM's will tri-state and you can check for a floating state on the data pins.

Chip select problems are usually associated with ROM* or MEM*. ROM* is the chip select for one or both ROM's while MEM* controls the data buffers for a ROM/RAM Read. You get both signals from DIP shunt Z71. You might check the DIP shunt for correct programming jumpers. The type of DIP shunt used by the TRS-80 has been known to develop cracks in the shorting bars during programming. Metal cracks are very likely to be present if the plastic part of the shunt is damaged.

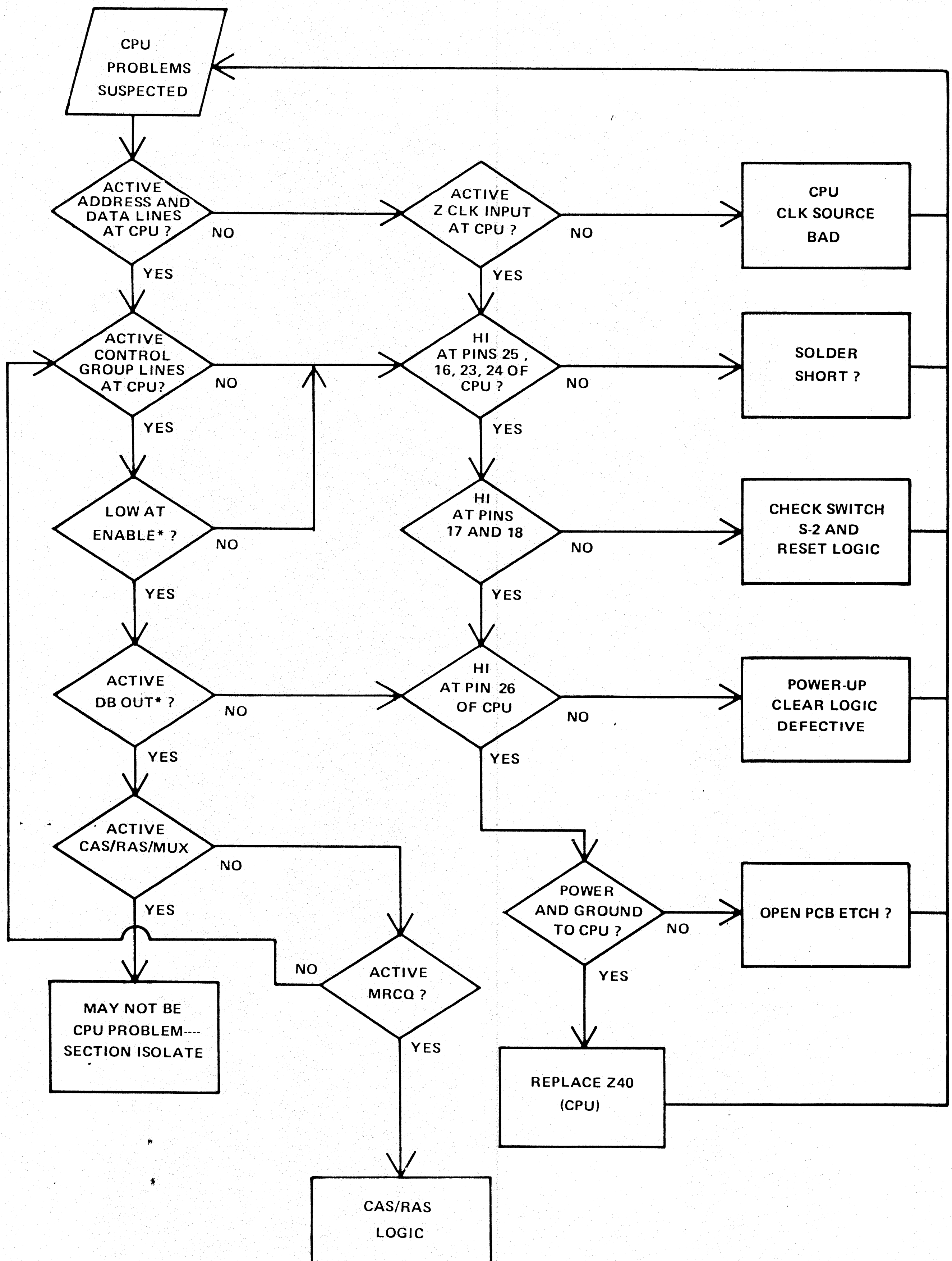

FIGURE 4. CPU FLOWCHART.

RAM

RAM problems are slightly more difficult to troubleshoot because of multiplexing of the address inputs. Aside from addressing differences, the RAM's are checked like the ROM's. Use SCQATS to dig out memory errors if possible. Also, be sure you check the three power supply voltages going to RAM; they are: –5, +5 and +12 volts. Insure that all voltages are present on all RAM's. Also check for bad RAM insertion – pins not in sockets or loose RAM's due to shipping vibration. Check for activity on RAS, CAS and MUX going to RAM and multiplexer. Insure that all specified addresses do indeed go to the multiplexer. RAM problems are most likely suspect after a 4K to 16K conversion. Be sure DIP shunt Z3 is programmed correctly for the amount of RAM in the system.

If you have a RAM problem and the system will not load SCQATS, you can replace the eight RAM's with a known good set. If this fixes the unit, start replacing your standard RAM's with the parts you took out, one by one. Power up after each exchange to see if you still have a "Ready". Continue this process until you have isolated the bad RAM(s).

CAUTION

When handling RAM's, be careful that you do not damage the parts because of static discharge. Before touching a RAM, ground yourself using a grounding strap designed for handling MOS devices – or momentarily touch the right side of capacitor C9. If you must transport MOS devices from one part of a room to another, be sure you have the parts in a conductive tube or in conductive foam. **DO NOT USE STYROFOAM!** Unless specially treated, styrofoam eats MOS devices like candy. It can generate tremendous static charges. Do not use cellophane tape to hold RAM's in sets of eight. The process of removing tape from the roll will act as a handheld static generator.

ADDRESS DECODER

A problem in the address decoder section will probably point you in the memory direction. For example, if the ROM is never addressed with ROM*, you'd think you have ROM difficulties. Therefore, if you suspect one of the "memory" locations, keep in mind that the address decoder sources the memory selects. The select inputs to the different memories should be the very first thing you check.

Failure of address decoding will usually be associated with one of the higher order address lines. You should check Z21's inputs for activity, paying particular attention to pins 14 and 2 of Z21. Z21's outputs also depend on the status of the shorting straps on DIP shunt Z3. Remember: You cannot test an open collector output unless there is a pull up resistor attached to it.

If Z21 and the DIP shunt appear OK, look for activity on the other inputs. For example, A12 and RD*. Maybe the CPU is constantly addressing one memory all the time, but is not getting any data in return. This is especially true of the keyboard "memory". If the CPU thinks there's a key depressed, it may lock itself into a loop, trying to isolate a phantom key.

KEYBOARD

Difficulty with the keyboard is usually mechanical in nature. Sticking keycaps, bouncy keys and a broken interconnect cable are common. Shorts in the keyboard matrix are usually easily detected. If you find an alphanumeric character displayed right after the "Prompt", that particular key, or PCB run, may be shorted. A completely "dead" keyboard could be caused by lack of power, a broken interconnect cable or the address decoder is not supplying KYBD*.

If you have a weak space bar spring, replace it with a 3 oz spring. If it still sticks, and there is no plastic flash that could cause sticking -- give the spring more muscle by stretching it a little.

If you lift a sticking keycap and find mangled switch contacts, don't scrap the whole keyboard, replace the contacts. The following is a step-by-step procedure for contact replacement:

1. Disassemble the unit.
2. Remove the keycap and keycap plunger.
3. Remove the spring.
4. Unsolder the contacts from the PCB. Be sure that the contact ends (protruding through the Board) are actually free. This is important when you are working on double-sided Boards.
5. Note the position of both types of contacts. The fingered contact is usually on the right side, with the keyboard oriented in a normal position.
6. Using a pair of strong needle-nosed pliers, pull both contacts out of the plastic base. Fine pointed needlenose pliers usually cannot grip the thin contacts well enough for extraction.
7. Insert a new contact set in tool #773-10000 or #773-10023, making sure that the contact fingers face each other.
8. Insert the tool with the new contacts into the key base. Press the tool firmly until it seats against the stops. Insure that the PCB is not resting on a hard surface because the tool will try to force the contact end through the PCB.
9. Extract the tool. Note that the new contacts are in proper position and the solder ends extend through the PCB on the opposite side.
10. Solder the contacts. Replace the spring, plunger and keycap. Check the key for proper operation.

KEYBOARD REPAIR PARTS

Description	Manufacturer's Part Numbers
Standard Plunger	171-40103
Solid Contact	173-30052-2
Split Contact	173-30053-2
2 oz. Spring	173-10012-4
3 oz. Spring	173-10012-2
Metal Insertion Tool	773-10000
Plastic Insertion Tool	773-10023

INTERCONNECT CABLE

When replacing the interconnect cable, be sure that you install the cable correctly. The contacts are inserted from the top side of the Board. The contacts are bent 90° to fit the holes in the two Boards. Be sure that the contact crimps are facing the Boards.

CAUTION

With the contact crimps facing up, stress is applied to the plastic interconnect cable and the contacts when the Board is installed in the plastic case.

VIDEO DIVIDER CHAIN

Problems in the video divider chain can usually be associated with the stability of the display. Loss of vertical or horizontal reference frequencies can sometimes be traced back to defective counters or bad Reset gates. Since the system master clock/oscillator is included in this section, inactive (dead) system troubleshooting can end up here.

Since most of the reference and timing signals for the video processor are generated in the divider chain, most (not all) display gripes may be isolated to this section. This is especially true of vertical roll or horizontal tear of the display. If the horizontal or vertical reference frequency is not getting to the sync processors, then the problem definitely is a divider chain screw up.

The major test point to check in the chain is the 60 Hz output at Z32, pin 11, using a frequency counter. If 60 Hz is found at this pin, then the chain is probably working correctly. If not, move up the chain, toward the oscillator, until a correct signal is found. Figure 5 shows a chart of frequencies that can be expected at each chain output. Slight deviations from the frequencies shown should be expected. The chart was drawn up using standard production-type units that tend to run slow by –.03%. The division ratio column shows the factor the master oscillator needs to be divided by, to calculate the signal frequency. For example: Assume that you measure 10.64100 MHz at pin 6 of Z42. Then the frequency of L1 is 10.64100 MHz divided by 1.344082×10^3 which equals 7916.93 Hz. It's just one Hertz away from the frequency listed for the chart's reference frequency. Expect small deviations, but large errors usually indicate a part failure.

If you do find a large error in frequency, move down the chart until you find a correct signal. **Do not automatically assume that you have found the bad part at this point.** Let's say that you are missing all signals past HDRV, but C32 is good. True, Z50 could be bad, but so could Z66, Z49 and Z6. The best way to truly isolate the bad part without blindly replacing chips is to cut runs. First, open the run from Z50, pin 11. Retest pin 11. Is it active now? If not, replace Z50. If pin 11 is active, repair your etch cut carefully and cut the etch at pin 5 of Z66. Retest pin 11. If it's now active, replace Z66; if not, repair your cut and continue the cut/test process until you have isolated the shorted run.

SIGNAL NAME	SIGNAL SOURCE	SIGNAL FREQUENCY	DIVISION RATIO	COMMENTS
UDRV	Z32 Pin 11	60.00 Hz	177.3517×10^3	Vertical Reference
R8	Z32 Pin 8	60.00 Hz	177.3517×10^3	Character "Row"
R4	Z32 Pin 9	180.0 Hz	59.11722×10^3	Character "Row"
R2	Z32 Pin 12	360.0 Hz	29.55861×10^3	Character "Row"
R1	Z65 Pin 12	660.0 Hz	16.12288×10^3	Character "Row"
L8	Z12 Pin 11	1.319 kHz	8.067550×10^3	Character/Scan Line
L4	Z12 Pin 8	2.639 kHz	4.032247×10^3	Character/Scan Line
L2	Z12 Pin 9	3.959 kHz	2.687825×10^3	Character/Scan Line
L1	Z12 Pin 12	7.917 kHz	1.344082×10^3	Character/Scan Line
HDRV	Z50 Pin 11	11.835 kHz	671.9987	Horizontal Reference
C32	Z50 Pin 8	31.670 kHz	335.9993	Character Column
C16	Z50 Pin 9	63.340 kHz	167.9997	Character Column
C8	Z50 Pin 12	110.840 kHz	96.00414	Character Column
C4	Z65 Pin 8	221.69 kHz	47.99991	Character Column
C2	Z65 Pin 9	443.38 kHz	23.99995	Character Column
C1	Z43 Pin 7	886.756 kHz	12.0003	NOTE 2
Chain	Z43 Pin 9	886.756 kHz	12.0003	Divider Chain Input

NOTES

1. All Frequencies and Division Ratio calculated using 10.641099 MHz (Master CLK Frequency [–.03% error]).

2. Signal Frequency shown is in 64 character format. Will be held low in 32 character format.

FIGURE 5. TABLE OF SIGNAL FREQUENCIES.

VIDEO RAM

If you suspect video RAM problems, you should try a SCQATS loading. SCQATS will be most helpful in rooting out bit error in the RAM s. If the test generates large amounts of bit errors, you should suspect either the divider chain or the video RAM addressing multiplexer. Multiple "Ready", "Prompt" and characters all point to RAM addressing errors.

Normally, addressing errors occur when there is a short or open between the multiplexer and the RAM s. Signal activity on the address inputs of the RAM s may be checked easily using an oscilloscope. All address lines (V0 through V9) should be active in 64 character format. There will not normally be any floating conditions on these inputs. The VWR* input to video RAM will only be active during a CPU data transfer. Normally, it should be high.

Addressing errors may also be rooted out by inspection of the display. Pull the BASIC ROM and turn on power. The screen should show @9's. If you get some @9's, examine the display carefully. If there are @9's missing in horizontal rows, then check the address inputs associated with row data (V6 through V9). If there are @9's missing in vertical columns, examine the status of the address associated with column data (V0 through V5). With a little experience, you will soon be able to recognize the pattern of @9's so that you can go directly to the bad address line.

When the display is flickering as it does in @9 mode, the CPU is constantly interrupting the divider chain's control over video ROM addressing. If you are looking at RAM addresses during this time, you will see the CPU's address flickering inside the divider chain's address. This is normal; as a matter of fact, it is abnormal if there does not appear to be two signals on the display. The lack of the address flicker could mean the multiplexer is not working correctly, or the CPU address is not getting to the multiplexer.

If you suspect a multiplexer is not switching properly, test it. First make sure the address line going to the multiplexer is OK. Then monitor the suspected output pin of the multiplexer and ground pin 1. The output should switch from the divider chain signal to the CPU address signal. If it doesn't, you've got a bad multiplexer – replace it. (This assumes, of course, that VID* is not held low all the time because of some other problem. It is not recommended that a logical high be forced on VID* in cases like this. You could damage Z36 in the address decoder section).

VIDEO PROCESSING

Problems in the video processing section can range anywhere from a blank screen to missing dots. Usually, the fault is easily found because this section is serial in nature. For example, if you have graphics problems, you know there are only two chips that are used as graphics handling devices. You would immediately look around shift register Z11 and graphics generator Z8. The parts that are strictly alphanumeric are character generator Z29 and its shift register Z10. Defective devices that can affect both alphanumeric and graphics are: Z26, Z27, Z30 and the video mixing circuit, consisting of Q1 and Q2.

The worst video problem you can possibly get is the blank screen. Where do you start? First off, test the power supplies for proper operation. Then check the master oscillator for operation. If they are OK, move down to the emitter of Q1 and look for video. Work your way backwards until you find signal activity. Before going too far, you might check to see if the character generator is receiving data. If so, you have the problem trapped between two points. Try to determine what the system wants to do. Is it trying to output alphanumerics? Look for activity at Z26, pin 8. If this point is active and pin 6 is always high, you've just eliminated some logic. Why isn't Z10 outputting? If it is outputting, maybe Z30, pin 2 is being held high for some reason. Maybe Z26, pins 8 and 6 are both high. What could cause this? Is Z27 working? Is flip-flop Z7 always reset? Maybe LATCH is not active. If so, both Z7 and Z27 will not operate.

Sometimes it helps in video troubleshooting to force a screen completely full of data. Pull BASIC ROM(s). The CPU will try to go into an @9 state. If nothing else, you will now have an easily recognizable 'scope pattern you can trace.

Since this section is serial in nature, here are a few aids you can use in your troubleshooting:

Dim Display – Z41 going bad. If Z41 is running hot, replace it. It's getting hot because the output transistor has increased its saturation voltage. The higher voltage does not allow the signal at the base of Q1 to swing low enough for proper video-to-sync ratio.

Missing Alphanumeric Dots – If you're missing dot rows on all characters, check the line count data going to the character generator. If these lines are OK, replace the character generator. If you are missing dots in vertical columns, check dot inputs to Z10. If OK, replace Z10.

Unstable/Flashing Dots – Sometimes Z10 will "miss" data on its input during a load cycle. This is usually heat associated. If the problem is cured or made worse by giving Z10 a shot of circuit coolant, Z10 must be replaced.

Missing Graphic Parts – Check input to Z8. If OK, check outputs. More than likely, you'll have a broken etch around Z8. Try to determine if you are missing "right" or "left" graphics. Missing vertical cell parts are usually associated with Z8, while a graphic cell with vertical streaks indicates a problem with Z11.

Unstable/Flashing Graphics – Usually harder to detect and not as common as unstable dots. But, same type of fix – replace Z11.

No Inter-Character Line Blanking – Problem with L8, the frequency divider chain or latch Z27.

Severe Display Interference – Usually not a video processor problem. Look at +5 volt supply bus. If you find oscillations, see why C12 or C13 (in 12 V supply) is not working.

Spelling Errors – A system that mis-spells words usually has data screw-ups in video RAM, or the data going to character generator Z29 is being grabbed by a short or defect around latch Z28.

SYNC GENERATOR

The Sync Generator section is one of the easiest circuits to troubleshoot. If the timing references are getting to Z6 and Z57, it is a simple process to find the point where you lose the signal. A problem can occur with the adjust pots, R20 or R21. Severe heat will cause these parts to fail. C20 and C26 are usually dependable unless they are physically crushed. You may find C21 or C27 shorted. These capacitors are mylar and are very susceptible to shorting out under impact stress.

An important point about this circuit: Z6 and Z57 are CMOS parts. Unlike TTL, they are high impedance devices that consume little current. A floating condition on a CMOS input will not necessarily give a floating "display" on an oscilloscope. A floating condition may look high or low depending on the charge of the broken line tied to the input. Even the Megohm or so, of finger pressure can give a path across a broken run and cause a CMOS part to operate. When you remove your finger from the run or pin, circuit operation may fade away very slowly as the PCB run discharges.

ADDRESS DECODER – EXPANDED DISCUSSION

Since the address decoder is made up of gates, it is extremely easy to fix once you find the problem. The hard part is knowing when to suspect a fault with the decoder section. Section Isolation demands that the address decoder be functional, at least partially. Unfortunately, there is no "cut and try" method to determine if this section is working correctly. Of course, you can monitor each output to see if it's responding, but you really can't be sure the signal is supposed to be there when it is. For example, you see ROM* and MEM* operate, but you are not really sure if the address specified ROM*. There are only two ways to be sure ROM* is supposed to be outputted, and they are: 1, look at all address lines going into the decoder and decode them yourself; or 2, force the CPU into a known ROM* loop using machine language or static address switching. However, neither of these two suggestions looks promising.

Usually, an address decoder defect will disable one of the other sections. If you get a "Ready" upon power up and no keyboard activity, KYBD* is easily checked for activity. Here we assume the decoder is bad at KYBD*; but there is no major problem with other sections because we do get the "Ready".

The same assumption is also used whenever we power up a computer that does not give a "Ready"; but gives us, instead, a recognizable pattern to use during Section Isolation. For example, the large colon display. You know how to generate the large colon display – pull DIP shunt Z71. Since you have large colons, with Z71 installed, what's wrong with the DIP shunt? If it appears OK, find out why RAM* is not active. Maybe DIP shunt Z3 is not working.

One important gate to consider when working with the address decoder is Z73, pin 6. If you do not get activity at pin 6, the whole decoder is going to be screwed up. Z73, pin 6 enables Z21, the device monitoring A12 through A14. If Z21 is never turned on, the address decoder will be absolutely dead. Z73, pin 6 should be the first signal you check in this section. Usually a lack of RAS* at pin 1 will kill Z73 (take that with a teaspoon of salt. If the CPU is completely lost, there's no telling what A15 will be doing. As the symbols on Z73 show, both A15 and RAS* must be low for a low output).

While you're bouncing around in the input section of the decoder, you should check address line activity. If you're fighting a lost CPU, you might find some signals that appear to be one state or the other. The steady state of an address line may try to lead you away from the address decoder, so you head toward the CPU, chasing a problem that exists only in the CPU's confusion. Try depressing the reset switch while monitoring the steady state address line signal. You should see a few pulses flow past the probe. At least you know something is coming out and you're not side-tracked.

The reset switch is a good test source to use when looking at decoder outputs too. During reset, the CPU is supposed to become quite busy. It must check ROM; stuff data in RAM; clear video and monitor the keyboard. Press the reset switch. Something should be outputted at all decoder outputs – at least momentarily. If you are still faced with a steady state high at a decoder output, maybe the ROM is never getting sourced for the reset routine.

Watch out when checking Z21's outputs without DIP shunt Z3 installed! Remember, Z21 is an open collector decoder device. Without Z3, the pull up voltage is not available. You might not see anything on one of these pins unless you pull the pin up to V_{CC}.

CASSETTE PROBLEMS

Most of the difficulties you'll find in this section will be caused by no recorder motor control. Usually, K1, a reed relay, will have gone bad because of over work.

Relay damage is particularly susceptible to BASIC II units. That buzz you hear every time you power up a BASIC II unit is the relay going bananas during the CPU's lengthy initialization routine. The power up routine and the added recorder usage, because of more efficient file storage routines, make K1 earn its living.

The contacts could remain closed due to contamination, or the relay coil could open or short. The relay is easily replaced, but watch out for Murphy's law. It is very easy to install K1 on the Board backwards. Be sure you match the index mark on the relay with the silk screen mark on the PCB (when backwards, Z41, pin 3 sees a short to V_{CC}. It tends to make Z41 get hot – fast). Damage to Z41's relay side will probably kill the video side. Suspect a shorted relay (or shorted diode, CR3) if the display slowly dims and fades away.

If you suspect K1 is stuck, thump the relay body with your finger. That should free the contacts, and the recorder will stop. Don't pat yourself on the back for a job well done, however, until you replace that relay. It may stick again on the next CLOAD instruction. Replace K1 and save someone some grief later on.

If you think you are having a cassette audio processing problem, you can check for activity at Z4, pin 10. Try loading a long program into the computer while monitoring pin 10. It should be normally high and go low on the audio pulses. So long as the pin is active and there are at least two pulses each bit time, you should be OK in giving Z4 a clean bill of health.

But, beware of a normally low signal at pin 10 of Z4! If you have active rectifier or level detector problems, pin 10 of Z4 can operate backwards. The output will be normally low and go high on tone pulses from the tape. The problem is usually associated with a shorted diode at CR4 or CR5, or the level detector may not have capacitor C39 charged up due to a failure at CR6, CR7 or C39. Consult the theory section for waveforms and operation of this circuit.

If you are getting good data to set-reset flip flop Z24 during a CLOAD fault, you may have a digital problem. Try to CLOAD a long program, like blackjack and see if Z24, pin 8 is active. Also check activity at Z44, pin 15. You'd better hope one of these signals is not right, or you've got a long day ahead of you.

During a CLOAD, OUT* resets flip-flop Z24. If Z24 stays set, suspect Z25, pin 8's gate – or follow OUT* back to its source. If INSIG* is messed up, examine Z25, pin 6 and follow IN* back to its source. If both of the signals look strange, check out port decoder Z54, Z52 and Z36, which combine to form FF*. If all signals and Z44 look OK, suspect a RAM, CPU or ROM problem in that order. It would pay if you are familiar with the timing of INSIG* and OUTSIG* in a CLOAD condition using a known good TRS-80. It would definitely help you in Section Isolation if you find yourself considering a ROM, RAM, or CPU defect.

A RAM bit error usually shows up in CLOAD when you find part of the loaded program correct and the other part garbage. Use SCOATS to dig out this type of error or, play the RAM swap game until you find the defective part.

A CPU problem is usually more common than a ROM problem in a CSAVE condition. This is true simply because you will be more concerned in getting a "Ready" on the screen than you are in seeing if the unit will CLOAD. If the CPU checks out good, you might re-examine the IN* and OUT* signals before considering ROM failure.

CSAVE problems usually point to software (ROM/RAM) or latch (Z59) difficulties. If your unit CLOAD's OK, try to CSAVE a program without using a tape in the Recorder. You can monitor the status of pin 5 of J3 for the output audio waveform. If you lack this waveform, check the status of R53 through R56 and OUTSIG* at pin 9 of Z59. Since D0 and D1 are the data lines used by Z59 during CSAVE, you might look at these two lines. Also check for a high at pin 1. You could have a solder short pulling pin 1 toward ground.

Did you ever come up to a 32 character display format that wouldn't go away? Z59 is handling this function in conjunction with the status of D3. OUTSIG* clocks the latch. If OUTSIG* works fine during CSAVE and CLOAD, suspect a defective latch. Also, Z59 , pin 14 could be shorted to ground. Try to clear latch Z59 by shorting pin 1 to ground for a second or two. If the display changes from 32 character to 64 character and stays that way, suspect a ROM or CPU software glitch. If the display goes from 32 character to 64 character, then back to 32 character format each time you short and release, you should suspect a defective OUTSIG* line. For some reason, OUTSIG* must be active all the time, or noise is triggering Z59 due to an open etch.

POWER SUPPLY

Most of the problems that result in loss of power supply operation will be associated with solder shorts, component shorts or bad adapters. Normally, the power supply will not be damaged due to a short because the regulators use current limiting with fold back. A solder short or shorted component does not have to be located in the power section to cause a supply problem. The short could be anywhere.

If you are missing +12 volts and +5 volts, measure the voltage across R18. This resistor monitors the current flow of the +12 volt supply. If the voltage reads .6 volts or so, the +12 volt bus is in fold back and has shut itself off. Since the +12 volt bus is shutoff, you will not have +5 volts because the +5 volt regulator is referenced to the +12 volt output. You will have to find and remove the short on the +12 volt bus before anything will work.

If you find that you are missing the −5 volt supply, first confirm that there is ample negative voltage on the adapter side of R19. See if R19 is dropping all of the voltage. If so, you have a −5 volt bus short (this assumes that CR2 has not been put in the Board backwards).

The +12 volt and the −5 volt supplies are used by system RAM. If you have problems with either of these two, suspect a RAM short. See if you can find a RAM that generates more heat than the others.

DANGER

Do not get in the habit of checking RAM temperatures by placing your finger on each part! A supply short in a RAM chip can heat them up to soldering temperatures. It is quite painful to discover the RAM manufacturer's Logo burned into your fingertips!

Pull all RAMs and retest. If all of the power supplies are now OK, turn off the power and re-install a RAM. Turn on the power and retest. Install each RAM until you find one that crashes the power supply. Remove the bad RAM and continue to check the rest of them. There may be more than one shorted device.

A short on the +5 volt bus can be a real headache. Unless you can see the short, you will have to cut runs to Section Isolate. Once you isolate the shorted section, you will probably still have to make other cuts to get down to the short. **Do not forget to repair your cuts.** And remember, these runs must carry considerable current. Use stranded or solid wire, − 22 gauge or larger, to repair cuts. (Never solder-bridge an etch cut; simple Board stress may open the solder-bridge or tear small runs loose from the Board.)

If you find a dead +12 volt bus, examine Q1's heat sink. The hardware holding the transistor/sink sandwich together may have loosened. The heat sink may have turned around and shorted against Q1's base or emitter lead. Depending on the force, it might have sheared one or more leads from the PCB. If you find a loose heat sink, shorted or not, retighten it.

Problems with the AC adapter are usually terminal. Either the fuse link in the primary winding has opened, or the wires were destroyed at the male DIN plug. If you find the fuse link blown, check rectifier package CR8 for shorted diodes. Replace the adapter in any case since field maintenance is not recommended.

Figure 6 lists the voltages found around Z1 and Z2 with a normal operating unit. The +12 volt supply has been adjusted for 12.00 volts and the −5 volt supply has been adjusted for 5.00 volts.

Z1 Pin Number	Z1 Voltage	Z2 Pin Number	Z2 Voltage
1	0.00	1	0.00
2	5.30	2	10.60
3	5.00	3	11.99
4	5.00	4	6.92
5	5.00	5	6.92
6	7.46	6	6.92
7	0.00	7	0.00
8	0.00	8	0.00
9	0.33	9	5.72
10	5.89	10	12.31
11	11.99	11	21.16
12	11.99	12	21.69
13	7.05	13	13.48
14	0.00	14	0.00

All voltages are measured with a digital voltmeter. Voltages are referenced to ground at the right side of capacitor C9.

FIGURE 6. TABLE OF POWER SUPPLY VOLTAGES FOR Z1 AND Z2.

HORIZONTAL AND VERTICAL ADJUSTMENT

After components in the sync generator are replaced or after other repair work, the horizontal and vertical centering should be confirmed. A centering tape should be loaded into the repaired unit and adjustments made accordingly. If you want to make your own tape, here is a sample program:

10 CLS

20 FOR X = Ø to 127

30 SET (X,Ø) : SET (X,47)

40 NEXT X

50 FOR Y = Ø to 47

60 SET (Ø, Y) : SET (~~27~~ 127, Y)

70 NEXT Y

80 FOR X = 62 to 65

90 SET (X, 23) : SET (X, 24)

100 NEXT X

110 GO TO 11Ø

The above program should be stored on a tape several times for easy loading. With multiple programs you don't have to rewind the tape each time you need the test program. It will run on both Level I and Level II machines.

The re-centering program draws a large graphics rectangle on the outside boundaries of the cell array. It also draws a center rectangle. Adjust R20 and R21 so that there are equal boundaries on all sides of the large rectangle. Use a non-metallic screwdriver so body capacitance does not interfere with your adjustments.

IT DOESN'T WORK – SOMETIMES

There is a well known rule of Murphy's Law that states: "A device will function properly whenever the operator is in a position to correct a malfunction".

There will come a time when you will find a TRS-80 that operates just great when it comes near a test bench. But when the moon is just right and the computer is away from the schematics and test equipment, the memory listing looks like some unknown language and the relay keeps time with the garbage on the display.

The only logical choice you have is to burn it in. Set up the computer in some unused corner and run the memory part of SCQATS. Hopefully, after a few hours, SCQATS will root out a spastic memory location. Try to keep the unit in the case for maximum heat retention. If all else fails, replace the RAM s as a set. Maybe replacing an entire set of RAMs will be less costly in time and labor than fighting a losing war with one bit.

If the problem appears to be in some other section where SCQATS is not effective, try to generate a program that will cause a constant failure. The only chance you have to fix an erratic problem is a faithful duplication of the malfunction. If the gripe states that, "For/loop statements crash part of the video section", then use For/loop commands in your program.

Maybe there is a cold solder joint that goes open every once in a while. Expect one of these when you find a problem that exists only if you flex the Board a certain way. See if you can localize the bad joint by tapping the Board with a non-conductive rod. Maybe you have a solder ball rolling around. Sometimes you can jar it out from under a socket by tapping the Board. If you're lucky, the ball may lodge somewhere and stay. Once you've got the problem to stay still, you've almost got it fixed.

Look on the etch side of the Board under the RAMs. You might find an installation error. A socket lead is easily bent. Maybe the lead was folded under the socket body and not soldered in a hole. There may be just enough pressure on the lead and the pad to allow spastic operation. Look for a smooth coating of solder instead of the pointed cone you would expect if a wire or lead was protruding through the Board. Don't limit your visual inspection to socketed parts only. It is possible to find a bent lead on a standard package, although it is not as common as a bent socket lead.

Another type of defect that can cause intermittent failure is the open feedthrough. See if you can find any solder-filled holes where the solder did not come all the way through the Board (the plating may be cracked inside the hole and the solder did not flow past the crack). Solder a small piece of lead wire through the suspect hole during repair. Defective feedthroughs usually occur in groups. If you fix one hole, look carefully at surrounding holes for other defects.

HINTS, IDEAS, SUGGESTIONS AND – WHAT NOW?

One of the advantages of digital computers is the repetition of basic circuits. Once you know how a basic logic cell works, it will operate in the same way all through the machine, no matter how many times it is repeated. The gate may not generate the same type of signal that another one did two inches away, but the output does respond in the same way under the same input conditions. One of the disadvantages of troubleshooting digital computers is the machine language software. There is some kind of program inside there, pushing the buttons and pulling the levers. Nobody has bothered to tell you exactly how it performs a task. You know it does exist though, like migrain potential, ready to give you a headache and a half. The theory manual gives a brief description of how the keyboard scan software operates, but the discussion never does get down to the nuts and bolts. So what do you do if you think the problem exists in software and the only way you can confirm your suspicions is to know exactly what software is doing? Before you could examine exactly what software was doing in the keyboard, you would have to get yourself an expensive logic analyzer, a ream of computer print outs, and spend a lotta time figuring out how the program operates. Unless you're willing to spend the time and money, software listings are not going to help in troubleshooting.

This section of the manual will give you hints and ideas to try when you're faced with software type problems that screw up the hardware. The hints will play the advantages against the disadvantages of digital troubleshooting and help you confirm or deny suspicions about where the problem really resides.

The Gate with the Static Output

How many times have you come across a logic element that has data screaming into it and an output that just sits there? Probably too many times, especially in a major area like the address decoder where you really don't need that kind of "hassle". Normally, you attach a 'scope to the gate inputs and see if output conditions are ever met. If you have two gate inputs and two 'scope channels, you'll do OK. But, you can get gray hair trying to analyze an 8-input NAND gate that way.

One useful technique you might try is the input short. When confronted with an unresponsive OR gate or NOR gate, short an input to ground. Normally, a ground short will not harm a TTL output. If you have a 2-input NOR gate, for example, you could short one input to ground and, if the gate is working properly, you should see the unshorted active signal pass through the gate. Move the short to the other input to see if that pin makes the output respond. If so, chances are that you've got a good gate -- try troubleshooting backwards.

When you need to check the outputs of a NAND or an AND gate, shorting inputs to ground is not going to help (unless the outputs are high for an AND gate and low for a NAND gate all the time). **Do not attempt a short to 5 volts. A short to 5 volts can damage a TTL output!** If possible, find a gate further up the line that will respond to a ground short and will cause one of the gate inputs to go high. An example of this condition can be found on the schematic in the video processor section. Z9, pin 4 supplies an inverted Latch signal to Z26. If you want pins 13 or 5 of Z26 to go high, short Z9, pin 3 to ground. You can also short the inputs to Latch Z27 and cause some highs on pins 12 or 4 of Z26.

If you tried the ground short technique and still did not get output activity, what then? Well, assuming that you met all input requirements, you have two choices: 1, the gate is truly bad, or 2, there is a ground or V_{CC} short to that output. To check for both quickly, cut the etch run (if possible) and free the output pin, then retest the gate. If you get output activity now, you have a run short. If not, replace that package -- it's bad. (Don't forget to repair your etch cut!)

If you suspect a short, analyze the voltage level of the gate output. A short to V_{CC} will show about 5 volts. A normal TTL output gives a level of about 3.7 volts (this applies to TTL only. CMOS outputs swing millivolts from the supply voltage). If you suspect a 5 volt bus short, follow the run to its terminal point. Carefully examine places where the run gets close to a 5 volt bus.

A ground short or a logical low short may be isolated the same way. Follow the run. A ground short may also be analyzed using an oscilloscope. Hook up a 'scope to the node that you think is shorted. Turn off the system power while watching the 'scope trace. If the trace does not move in the vertical position, the short is to ground. If the trace moves up, then down, when power is removed, the run may be shorted to another TTL output. The 'scope method is also useful in determining if the output transistors in a gate are active.

Types of Shorts

There are five common shorts. They are as follows:

1. the solder splash short

2. the solder ball short

3. the solder hair short

4. the etch short

5. the defective component short.

The solder splash short is probably the most common in the field. This short develops due to excess solder and/or careless repair techniques. A solder bridge can develop between two pins on an integrated circuit during installation because of excess solder or too large a soldering iron tip. The true solder splash results when a soldering iron loses a bubble of solder, and the TRS-80 is on the receiving end. Usually, a splash is easily detected. They are big and cold soldered to several runs.

The solder ball short usually develops between the time the factory builds the computer and the time the customer picks it up. The birth of a solder ball is at the factory's wave solder machine. During soldering, hot gasses will expand and blow liquid solder into the air over the Board. The air partially cools the solder and it sprinkles down on the computer already formed into little spheres of varying sizes. The balls stick to the Board because of the moist flux. The cleaning process cannot break all balls loose, so a few stay on the Board. If the balls are small enough or hidden, they may not be detected unless they cause a problem during factory testing. During packing and shipping, the solder ball may break loose and roll around until it becomes lodged under a socket or wedged between runs. The customer ends up with a dead machine and you end up cursing the factory.

The solder hair is an extremely fine sliver of solder that can short unprotected runs. Solder hairs usually develop when a solder coated etch is rubbed with a sharp tool or an abrasive material. Impact stress causes the coating of solder to surface splinter. The splinters are then dragged across runs by hand or by vibration. If you cut runs when trouble shooting, take care that you do not over cut. If you do, re-flow solder cut marks you accidently made in the runs with the iron to melt the splinters. Never, NEVER, **NEVER try to clean solder pads on the TRS-80 with steel wool or a sharp tool!** A rubber eraser, used with light pressure, is all that is necessary if any cleaning is needed at all.

An etch short, to the factory, means "incomplete copper removal between circuit runs during Board manufacturing". The etch short in the field would show up as damage to a Board run. Heat was used to force the copper and base material to join, and heat can take the copper right off again. Excess heat during soldering or letting the soldering iron rest against a run can cause the pad, or run, to slide. The pad doesn't have to slide too far to short nearby circuit runs.

The component short is the defective gate or bad diode. There is not too much to mention here. Component shorts between a power bus and ground will usually fold back the power supply.

Logic Shorts

Two or more TTL gate outputs may become shorted together and create strange problems. Some functions may work, while others may not. Multiple shorted gate outputs may be recognized by finding a tri-state looking signal where there isn't a tri-state device driving it. A tri-state signal will have true logical high and low voltage levels. There may be places along the waveform where the voltage level is between a high and a low. Look on a data bus line to see a typical tri-state wave shape. A TTL output belonging to a gate that is not tri-stateable should never have three logic levels. If you find a screwed up wave shape, follow that run, checking nearby runs as you go for another messed up signal. When you find the two bad signals, inspect the run closely for shorts. If you don't find any shorts, keep tracing until one of the runs terminates. The two runs may come together somewhere else on the Board.

The counters used in the divider chain are 74LS93's. This family of TTL ripple counters sometimes shows a multi-level high on the data outputs. The wave shape appears to have one or more steps while the main pulse is high. This type of output is satisfactory if the steps do not fall below the 2.4 volt minimum logical high level. Usually, you will have a counter step of about half a volt or so, and the lowest step will never fall below 3.0 volts. This is just a little tidbit that could side track a technician who is not familiar with the '93 counter.

Address and Data Line Shorts

A short in the address or data lines is about the worst problem a computer can have. The two busses go everywhere; and it only takes a small flake of solder to kill a system as dead as shooting it would. If the two busses were rated as to which is worse to have a short, the data bus would win. Since the data bus is a two way street, everything attached to it is tri-stateable. You cannot really separate two shorted lines from the rest, because they all look strange. On the address bus, there are no tri-state devices (there are buffers used, but they are never tri-stated during normal operation).

Address line shorts are rather straightforward. Try finding two signals with tri-state looking voltage levels. (The CPU address buffer is not tri-stated unless the "Test" input is grounded at the expansion connector.) After finding the two bad lines, you can follow one around the Board until you find an area where the two runs come close to each other. If you still can't find the short, try cutting one run until you've isolated the area where a short exists. Be sure you repair each cut after each check. Don't leave them for later, you might forget where you made the cuts and create even more problems.

Data line shorts need to be isolated in the same way, once you find the two bad lines. Finding the bad lines is another matter altogether. The best way to search out shorted data lines is to disable the Data Bus. Short to ground the signal, TEST*. All data and address line buffers will tri-state. If you suspect a gate short to data line, look at all data lines. You are looking for one that is not floating. With a short between data lines, you will need to pull up a line to 5 volts with a 4.7K resistor and check on the other lines for a high, instead of a floating condition.

If you spend a lot of time hunting bus shorts, you might want to build yourself a little test board. The board could contain pull up resistors, LEDs and switches. You can connect this type of fixture to the expansion connector and rapidly determine if you have a bus short or not by switching ground to each line and see if any other lights go on. It's better than trying to grow a third arm so you can handle the pull up resistor, the 'scope probe and the shorting lead all at the same time!

Bent Pins

On socketed parts, it is easy to replace devices for troubleshooting. But, be careful that you do not cause more problems by getting in a hurry. On RAMs, it's extremely easy to bend an IC pin between the socket and the part. Suspect a bent pin if the part is hard to insert; and, upon more pressure, it suddenly snaps in. Make it part of your isolation routine to peek under the CPU chip and look for folded-under leads. The decoupling capacitors near the RAM may prevent you from looking at these sockets. However, you can usually inspect the RAM leads from the top of the Board. You can also check that the RAMs are level and of uniform height. Maybe a RAM has been loosened and only one side is attached. A quick push on the loose part may be all that's necessary to fix a malfunctioning unit.

DIP Shunts

It's been said before, but it needs to be said again. Be careful when programming DIP shunts. If undue stress is applied to a DIP shunt while programming, the plastic may crack. The crack usually develops in the center of the part in line with the shorting bar's narrowest point. The bars may separate enough to cause an open. When you program a DIP shunt, first install the part in the socket. Use a scribe to break the bars you need to open. Use only enough pressure to break the bars (don't try to drive the scribe through the Board). Be careful when you break bars near pins 1 and 8 as this is the weakest part of the shunt.

If you suspect a cracked shunt, OHM out the unbroken bars. Do not press hard on the meter leads. You might temporarily close a cracked bar and it'll read OK. If you find a defective bar, replace the shunt. Solder a broken shunt only if a replacement is not available.

ASSEMBLY STEPS

1. Turn the CPU Board upside down and install it in the plastic base. Make sure that the Board rests on the boss shoulders. Insure that the DIN plug Bezel has been installed.

2. Install the five rubber spacers on the keyboard bosses.

3. Position the keyboard over the bosses. Make sure that all the bosses pass through the keyboard holes on the PCB. Check the interconnect cable to see that it does not extend past the base lip. If so, gently push it back inside the base.

4. Install the LED in the socket and slide the collar over the socket (this step is only necessary with keyboards that have LEDs on long leads). Insure that the leads will not be pinched between the bosses.

5. Place the top of the case over the keyboard.

6. Turn the unit, keyboard side down, and install the six screws. Be sure that you install the three lengths of screws in their proper locations. Also, be careful not to scratch the keys.

7. Paint one screw head with warranty lacquer (you might as well use the same screw hole as before).

8. Install and tape down the Expansion port access door.

9. Burn in the unit using the SCQATS test program. This program is a convenient test source regardless of what was repaired. Examine the CSAVE function if you made repairs in this area.

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