MY ADVENTURES WITH HARD DRIVES

Part 8 - Radio Shack Hard Drives and the "Three Wires"

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INTRODUCTION

How many of you have opened up a Radio Shack hard drive box, attempted to remove the bubble (the actual hard drive), and discovered the infamous three wires (orange, white , and yellow) soldered to various places on the PC board of the bubble itself? Rather daunting when you first discover this little bit of circuitry.

Some time ago, I made reference to these wires in an earlier article of this series, promising someday to explain what they are all about. Recently I had to chase out all of these in order to accomplish a special task, and this seems like a good time to publicly document them.

FEATURES PROVIDED

While the wires appear to be a haphazardly applied afterthought, the underlying principles make pretty good sense when you understand the why's and wherefore's.

One of the purposes is the implementation of hardware Write Protect (WP) on the hard drive. Radio Shack thought this was a desirable Feature, and proceeded to add it to their design. The drawback is that all partitions within the drive will be write protected or none will be. If you want to write protect only one partition, use the software WP provided in the DOS. See the SYSTEM command for further details. l personally never use the hardware WP, but I keep it available in the drives I sell.

Another feature was an activity light. Of course, almost every bubble has its own activity light, but RS decided to have a consistent front panel for all their master and slave drives regardless of size. Furthermore, RS allowed for the use of a master and up to three slave drives, and the activity lights also serve as select lights, showing which drive is active at any given moment. Those of you who have only one 5 Meg drive may never have realized that that lonely green light staring at you is saying, "Drive :X is selected". If you have two or more drives, then only one will show a standing green light, whichever was last selected. Of course you know that the light blinks off briefly when the drive is being written to or read from. When you understand that the green light is both a SELECT light and an ACTIVITY light, then the extra wires make better sense. This is only true of the 5 Meg units and some of the 12 and 15 Meg units which also had the old (large) hard drive controller board (HDC). The later drives with the newer, small HDC have the select light normally dark, winking on when the heads are stepping.

The slave units function in the same manner as the older master units. That is, the green light is on when the drive is selected, and flickers off when it is stepping.

If you have opened a slave drive box, you know there is a FOURTH wire in those boxes. This provides the automatic turn-on feature so that no key switch has to be operated on slave drives.

FUNCTIONAL PRINCIPLES

Now do RS's circuits operate? To implement write protection, RS added several pieces of logic to the hard disk controller board (HDC), and made use of some unused wires in the 20 conductor and 34 conductor drive cables. The write protect circuit consists of the red lamp, the push on-push off switch combined with it, trace number 5 in the 20 conductor cable, and a couple of gates on the HDC. If you try to write to a protected drive, an AND gate will detect this and trigger an interrupt in the operating system, which immediately terminates the attempted write.

The activity light circuitry has two inputs. The first of these is the drive SELECT* circuit present on every 5 inch HD and which is normally connected to an LED on the front of the bubble. RS omits the LED on the bubble and utilizes the select logic to provide a signal to an additional circuit in the master or slave box consisting of one or two chips which control the filamentary green lamp on the front of the box. Radio Shack also chose the SEEK COMPLETE* signal which is fed back from the bubble to the HDC on line 8 of the 34 conductor cable. By suitably inverting and ANDing these two signals in the lamp driver circuit, RS causes the green light to flicker on the selected drive, thus the green tight shows when the drive is selected and flickers when its heads are seeking. Due to design differences between the older and newer HDC's the old boards caused the green light to be normally ON on the selected drive, flickering OFF when the drive is stepping the heads. The later HDC has the green light normally OFF, flickering ON only when the heads are stepping.

The last function, which occurs in slave units only, is the automatic turn-on. When the master drive is powered up, it sends out 12 volt DC on line 7 of each 20 conductor slave cable, The fourth (yellow) wire in a slave drive feeds the 12 V to a relay which responds by turning on the power supply in the slave drive.

HARDWARE DIFFERENCES

Historically, all of the above (except the auto power-on) was first applied to the 8.4 Meg drive, which was the first HD offered by RS. The circuits in that package set the pattern for all following TRS HD's up through the 70 Meg drive.

As each new (larger) bubble was selected by Radio Shack for sale in the marketplace, the connection points of the three wires had to be solved all over

again, especially since not all drive manufacturers used the previously chosen lines in the ribbon cables in the same way. Fortunately, RS used Tandons for most sizes, and there is commonality among those drives. The 35 Meg drive is by Quantum, and I have never seen the 70 Meg drive so I do not know which vendor supplied the bubble used in it. Anybody know for sure?

Two different hard disk controllers were used, one known as the 8X300 board (this is the old, large board), and the other is the WD-1010 (newer, small board). (The numbers correspond to a particular large chip on each board). The early, large board was used in the 5 Meg drives and some of the 12 and 15 Meg units. The small board was used in the 12, 15, 35 and 70 Meg drives. There are some differences between them. The write protect logic is similar, and the 12 volt feed to the auto-on circuit in the slaves is the same, but there is a small difference in the SELECT/RUSY lamp driver circuit. The old (8X300) board uses a 75453 chip, which has a two input NAND gate in it. The newer (WD-1010) board uses a 75452 chip, which has EL two input AND gate. A 74LS14 inverter gate is added to invert one of the inputs, making one input active high and the other active low.

The later board has a jumper to connect either E-13/E-14 or E-14/E-15 to allow the Write Protect to be disabled or enabled, respectively.

There is also another version of the WD-1010 board, sold as an external, stand alone unit under catalog No. 26-1138. This has some jumpers and trace cuts, but was originally the same WD-1010 unit sold for use with the 15 Meg drives. The trace cuts can be easily restored and the jumpers can be removed to make it identical to the WO-1010 in the 15 Meg drive. The jumper at E-13/E-14 has to be shifted to E14/E-15 to make the write protect circuit operational.

And then there is the slave drive! Since it has no HDC, R/S had to provide some logic for the WP and SELECT lamp circuitry. They created a little board with a 75413 on it which contains two lamp drivers, each controlled by a dual input NAND gate. This board mounts in the slave HD box near the power supply, and connects to the front panel switches and also via three wires to the bubble. The slave drive also has a fourth (yellow) wire which comes from a point on the bubble and runs to the coil of the power relay. This arrangement uses 12 Volts from the master drive to turn on the slave power supply.

Note that the colors of the three wires in a master drive do not match the corresponding wires in the slave drive! RS, in their infinite wisdom, used a different set of colors for the wires, see table 1.

SUBSTITUTION OF BUBBLES

Quite a few people have wanted to replace a small R/S bubble with a larger unit. There is no problem in doing this if you know what to do with the three wires, (four in the stave box). Items to be considered are as follows:

1. Only one pullup resistor pack should be in use, just like floppies. If you have more than one HD, be sure to remove the resistor pack from the slave drives.

2. Connect the three (or four if it is a slave) wires. See Table 1 for details. Use the connection information under the "generic" column heading. Because the line chosen by RS for the write protect signal has been used differently by the various bubble manufacturers, it is important to insure there is no feedback of +5 or +12 volts into the internals of the bubble. To be sure of this, read and follow the notes in Table 1.

3. Rework the partitioning to fit the larger drive. Items to be input to the driver when creating new partitions include:

Drive number (1 if you have only one bubble, 1 or 2 if you have two).

Step rate (try 10 microseconds, use it if it works; otherwise set for 3 or 4 milliseconds). Whatever works!

Number of cylinders, 1024 maximum.

Number of heads, 8 maximum

Note from the Legal Eagles:

As always in modifications and advice of this sort, anyone who opts to do the changes is doing so at his own risk! The author has offered his best advice, but will not be responsible for consequential damages of any sort. (I think that's the way the lawyers phrase it!)

GENERIC CONNECTION OF THE THREE WIRES

The original Radio Shack connections of the three wires were always to unique points on the PC boards of each different bubble. While this was fine for assembly line work where the same bubble was used repetitively. It is a complete pain whena user like us wants to connect a strange bubble in place of the original RS bubble. To solve this problem, I have worked out alternate connections which are usable for any MFM bubble with the ST-506 interface, not just the original RS units.

By soldering the three wires in the master to the HDC, instead of to the bubble, the bubble can be easily swapped in the future as desired without disturbing the three wires. This can be accomplished by soldering the three wires to specific points on the HDC, (which is where the three wires end up anyway).

Since there is no HDC in the slave drives, and since there is a fourth wire to deal with, I don't recommend messing around with them. Put a bigger bubble in your master, and don't use the slave! For those who insist, I have included the slave unit in the table, but it is not as simple as the master drive. I have determined where on the cables to connect each of the wires. Two wires need to be cut free, from the 20/c edge card connector to prevent feeding 5 or 12 volts into the hard drive (bubble). These two wires are then spliced to two of the four wires from the front panel. The other two front panel wires need to be spliced onto two wires in the 34/c cable, but the wires in the cable are left intact.

Table 1

Wire Color	Function	Original Tandon Connection	Generic Connection
Early Masters with large HDC's, 8X300 type			
Orange	Write Protect*	TP18	Pin 6 of HDC Resistor Pack R27 Note 1
Yellow	Drive Select*	U21-8	HDC J6 Pin 26 Note 5
White	Seek Complete*	U7-5	HDC J6 Pin 6 Note 5
Late Masters with small HDC's, WD1010 type			
Orange	Write Protect*	TP18	End of HDC R54 nearest J10 Note 2
Yellow	Drive Select*	U21-8	End of HDC R23 nearest U23
White	Seek Complete*	U7-5	End of HDC R38 nearest U28
Slave Units (No HDC's)			
Yellow	12 V Power On	TP-19	Line 7 of 20/c cable Note 3
Blue	Write Protect*	TP-18	Line 5 of 20/c cable Note 4
Orange	Drive Select*	U21-8	Line 28, 30, or 32 of 34/c cable Note 6
Brown	Seek Complete*	U7-5	Line 8 of 34/c cable

Notes

1. Solder wire to feedthrough near pin 6. Cut trace to Pin 5 of J1 to prevent feeding 5 V into the 20/c cable.

2. Cut trace to Pin 5 of J6 to prevent feeding 5 V into the 20/c cable.

3. Cut Wire #7 in 20/c cable to prevent feeding 12 V into the bubble.

4. Cut Wire #5 in 20/c cable to prevent feeding 5 V into the bubble.

5. Use empty pin hole of J6 instead of J5.

6. Select wire # to agree with drive :1, :2, or :3

LAZY MAN'S SOLUTION

The Lazy man's solution for the WD1010 (new) HDC. Disconnect the three wires from the bubble in the master unit, tape the ends and tuck them out of the way. Move the jumper on the HDC to join E-13 and E-14. This disables the write protect circuit for the master and all slave drives and both lights of the master drive, but the drive works OK. This scheme won't hurt anything and you can use software Write Protect function.

The lazy way on the old 8X300 HDC is to cut and tape the white and yellow wires. Connect the orange wire through a 470 ohm 1/2 watt resistor to a source of +5 volts. This is necessary to prevent the logic from setting a permanent write protect signal on the master bubble.

On a Slave drive with the new, small HDC, connect the fourth (yellow) wire to wire #7 of the 20/c cable to get the 12 V to operate the power relay. (Or, you can use a manual switch to bypass the relay). Cut and tape the other three wires. You also must move the jumper in the master drive to E13-E14. If you forget this jumper, the hard drive will be permanently write protected! No harm done, you just can't write to the drive. Use software WP with this setup.

If you have the old HDC, connect the yellow and blue wires as shown in Table 1. Cut and tape the other two wires.

CREDITS

Dave Dalager of Arlington, Texas is very knowledgeable of these drives, and I wish to thank him for his helpful advice. He offers the following useful recommendation:

Connect a 470 ohm, 1/2 watt resistor across the red lamp socket on the front of each drive. The purpose of this is to allow the write protect to function regardless of the lamp. Without this, you may suddenly discover your hard drive has become write protected for no obvious reason; the real reason being either a burned-out lamp or one which makes poor connection in its socket.

COMMENTARY

Unfortunately, the Radio Shack Technical Reference and Service Manuals are not very helpful in working out the connections of the three (or four) wires.

Radio Shack's practice in all of their manuals is to show explicitly what is on the printed circuit boards, and to include some details of the interconnecting cables. The problem is they don't clearly show which wires in which cables go to which PC board terminals. In other words, they don't show interconnecting wiring diagrams. I have seen enough of their different hard drives to document their design, and Table 1 is the result of that review and analysis.

REFERENCES

Since the 12 and 15 Meg units were manufactured with both the old and new HDC's, and since a common Service Manual was issued for those drives, that Service Manual, Cat No 26-4155, identified with MS2604155-584 on the rear cover applies to both HDC's. Since the manual also includes data sheets on the 5, 10, 12, and 15 Meg Tandon bubbles, and the difference between drives of different sizes is minor, that manual effectively covers the whole RS line, I recommend it as the one to obtain if possible. Availability is another matter; I don't know for sure if RS is still offering that manual for sale, but try for it if you want a general purpose manual to cover the RS boxes.

Other useful references include:

1. Radio Shack has a 62 page publication entitled "Radio Shack Hard Disk System Startup - TRS-80 Model 4/4P". Apparently it was part of the Model 4/4P DOS manual for hard disk systems. I found this manual to be helpful, although it assumes the use of the Radio Shack HD drivers. It also has a section on installing CP/M on a RS HD. It has the following two numbers on the rear cover:

    TSA8749650
    TAP8749531-8/84-BCo

2. If you use the MISOSYS hard disk drivers RSHARD5/6 with TRSDOS or LDOS, an instruction leaflet is included. While rather terse in style, the information is there. Very useful, comes with the driver software package from MISOSYS.

3. Radio Shack Service manuals for the various drives. Ask for the Service Manual for your hard drive by size in Megs and/or by the 26-xxxxx Catalog number from the bottom of the box.

The 5 Meg unit is Cat No. 26-1130. The Service Manual has No. 8749403 on its rear cover.

The 15 Meg unit is Cat No. 26-4155. The Service Manual has No. MS2604155-584 on its rear cover.

The 35 Meg unit is Cat No. 26-4171. The Service Manual has No. MS2604171-1084 on its rear cover.

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