

Modifying a CCS 2422 Rev A Disk Controller for Rev B/C Compatibility

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Background

California Computer Systems made significant changes to their 2422 Floppy Disk Controller board between Rev A and Rev B. These changes make the Rev A boards incompatible with the later Revision boards in several ways. A few simple modifications will make a Rev A board compatible with the later rev boards for Shugart disk drive compatibility. Further modifications are required for PerSci disk drive compatibility. With the addition of an adapter cable, you can control both Shugart-type drives and PerSci drives at the same time with the CCS 2422 controller. This paper describes these modifications, as well as how to interface to various 8" disk drives and some hints about how software can work with various drives on this controller.

Revision Differences

These are the differences between the Rev A board and the later rev boards that result in incompatibility.

	Rev A	Rev B & C	Affects Shugart	Affects PerSci
Status Reg 2 bit 3	2/4 MHz	Side Select	Yes	Yes
Control Reg 2 bit 2	No Connection	Remote Eject	No	Yes
J2 Pin 2	No Connection	-Side Select Jumper C2	No	Yes
J2 Pin 4	No Connection	-DS4 Jumper B1	No	Yes
J2 Pin 6	No Connection	-2 Sided (from drive) (Also Jumper E1)	No	Yes
J2 Pin 8	No Connection	-Index (same as J2 Pin 20)	No	Some
J2 Pin 10	-2 Sided (from drive)	-2 Sided/-Seek Complete Jumper E2	No	Yes
J2 Pin 14	-Side Select	-Side Select/Remote Eject Jumper D2	No	Yes
J2 Pin 16	No Connection	-Head Load & -DS3 Jumper A2 (Same as J2 Pin 18)	No	Yes
J2 Pin 32	-DS4	-DS4 Jumper B3	No	Yes

Modification for use only with Shugart-type Drives

The following modification will allow a Rev A Model 2422 Disk Controller work with Shugart-type drives, with software written for later revision Model 2422 Disk Controllers. Note that steps 1 and 2 are required even if only 5-1/4" drives are used.

1. Cut trace to U25-13. A good place to cut this trace is on the component side of the board, near U25-9, where this signal meets a via. (This removes 2/4 MHz from Status Register 2.)
2. Jumper from U25-13 to U12-14. (This connects Side Select to Status Register 2.)
3. Jumper from U8-29 to U11-12. (This brings TG43 to an inverting driver.)
4. Jumper from U11-11 to J2-2. (This puts the -TG43 signal on J2-2.)
5. Remove the FAST SEEK jumper. (Doesn't really matter if the BIOS is good.)

Modification for use only with PerSci drives, Models 277, 299, or 299B

The following modification will allow a Rev A 2422 Disk Controller work with PerSci Models 277, 299, and 299B (dual single-sided, single density) drives, with software written for later revision 2422 Disk Controllers.

1. Cut both traces to U3-11, one on the solder side and the other beneath U3 (which requires removing the chip or socket). (The frees the –CLR pin of the HLT-delay one-shot.)
2. Cut trace to J2-10. (This removes -2-Sided from J2-10.)
3. Jumper from U3-3 to U3-16 (re-connecting the –CLR pin to +5V).
4. Jumper from U25-2 to J2-6. (This puts -2-Sided on J2-6.)
5. Jumper from U3-11 to J2-10. (This clears the HLT-Delay one-shot with the –Seek Complete signal from the drive.)
6. Jumper from U3-11 to R-pack Z2-2. (This puts a pullup resistor on the –Seek Complete signal.)
7. Cut trace to U25-13. A good place to cut this trace is on the component side of the board, near U25-9, where this signal meets a via. (This removes 2/4 MHz from Status Register 2.)
8. Jumper from U25-13 to U12-14. (This connects Side Select to Status Register 2.)
9. Jumper from J2-2 to U10-10. (This connects –Side Select to J2-2.)
10. Jumper from J2-4 to J2-32. (This puts –DS4 on J2-4.)
11. Cut trace to J2-18. (This removes –Head Load from J2-18.)
12. Jumper from J2-16 to U10-11. (This puts –Head Load on J2-16.)
13. Jumper from J2-18 to J2-30. (This puts –DS3 on J2-18.)
14. Set the FAST SEEK jumper in the SFT position.

If the PerSci drive supports Remote Eject, then also do the following modifications:

1. Cut the trace to J2-14. (This removes –Side Select from J2-14.)
2. Jumper U12-5 to U13-13. (This connects data bit 2 to Control Register 2 bit 2, for Remote Eject.)
3. Jumper from U12-6 to U9-5. (This connects Remote Eject to an open-collector driver.)
4. Jumper from U9-6 to J2-14. (This puts –Remote Eject on J2-14.)

Modification for use with both Shugart-Type Drives and PerSci Drives

Using this modification requires building an adapter cable, as described below. Also, the drives must be configured as described below. Modify the Rev A 2422 Disk Controller as follows:

1. Cut both traces to U3-11, one on the solder side and the other beneath U3 (which requires removing the chip or socket). (The frees the –CLR pin of the HLT-delay one-shot.)
2. Cut trace to J2-10. (This removes -2-Sided from J2-10.)
3. Jumper from U3-3 to U3-16 (re-connecting the –CLR pin to +5V).
4. Jumper from U25-2 to J2-6. (This puts -2-Sided on J2-6.)
5. Jumper from U3-11 to J2-10. (This clears the HLT-Delay one-shot with the –Seek Complete signal from the drive.)
6. Jumper from U3-11 to R-pack Z2-2. (This puts a pullup resistor on the –Seek Complete signal.)
7. Jumper from U8-29 to U11-12. (This brings TG43 to an inverting driver.)
8. Jumper from U11-11 to J2-2. (This puts the –TG43 signal on J2-2.)
9. Cut trace to U25-13. A good place to cut this trace is on the component side of the board, near U25-9, where this signal meets a via. (This removes 2/4 MHz from Status Register 2.)
10. Jumper from U25-13 to U12-14. (This connects Side Select to Status Register 2.)
11. Jumper from J2-4 to J2-32. (This puts –DS4 on J2-4 and J2-32.)
12. Set the FAST SEEK jumper in the SFT position.

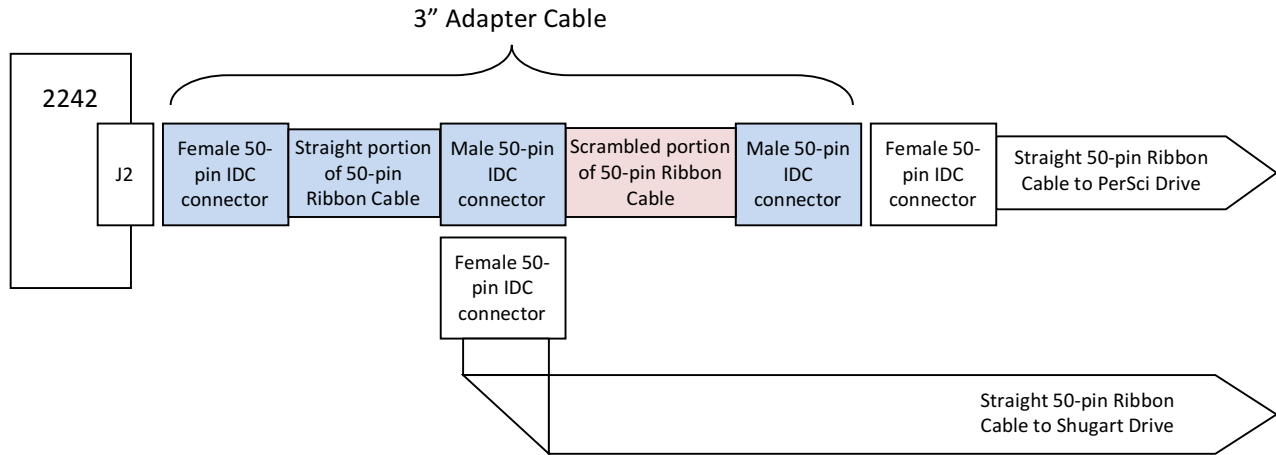
If any connected PerSci drive supports Remote Eject, then also do the following modifications:

1. Jumper U12-5 to U13-13. (This connects data bit 2 to Control Register 2 bit 2, for Remote Eject.)

2. Jumper from U12-6 to U9-5. (This connects Remote Eject to an open-collector driver.)
3. Jumper from U9-6 to J2-12. (This puts –Remote Eject on J2-12.)

Adapter Cable

The following adapter cable allows Shugart and PerSci drives to coexist on the same CCS disk controller. Both drives can be configured as shown later in this document. Fabricate a short (3") adapter cable like this:



The Adapter Cable can be fabricated by starting with a ribbon cable that is a couple of inches longer than the final adapter will be. Crimp the left two connectors (for the CCS 2422 and the Shugart drive) in place, about an inch and a half apart. Slit the ribbon cable for a couple of inches between the groups of wires in the table below. Carefully route the groups of wires to the right-hand connector (for the PerSci drive), according to the following table, and clamp the connector shut. Trim off the excess ribbon cable.

CCS 2422 End	Even Signal (odd signals are GND)	Shugart End (straight through)	PerSci End (scrambled)
1,2	-TG43	-TG43	No Connect
3,4	-DS4	-DS4	3,4
5,6	-2SIDED	-2SIDED	5,6 (1)
7-10	(Unchanged)	(Unchanged)	7-10
11,12	-Eject	(Ignored)	13,14
13,14	Side Select	Side Select	1,2
15,16	-Head Load	(Ignored)	No Connect
17-18	-Head Load	-Head Load	No Connect
19-22	(Unchanged)	(Unchanged)	19-22
23,24	-Motor On	(Ignored)	23,24
25-28	(unchanged)	(unchanged)	25-28
29,30	-DS3	-DS3	17,18
31,32	-DS4	-DS4	31,32
33-50	(unchanged)	(unchanged)	33-50

1. Pin 6 of a PerSci 277 must be disconnected

Shugart SA800 Configuration

Here are the Shugart SA800 Jumper settings for use on a CCS 2422, potentially sharing the interface with a PerSci drive.

Jumpers	Jumper Position	Comment
T1, T3-T6	Jumper for termination	Not Jumpered if the PerSci drive is terminated
DS1-DS4	See Below	Drive Select
RR	Jumper	Radial Ready when removed
RI	Jumper	Radial Index & Sector when removed
R	Jumper	Ready Output to interface pin 22
800/801	800 Jumpered	Soft-sectored disks
I	Jumper	Index output to interface pin 20
S	Open	No Sector output to interface pin 24
DC	Open	No Disk Change output to interface pin 12
HL/DS	HL Jumpered	Stepper power from Head Load & Door Closed (note A,B,X)
WP/NP	WP Jumpered	Write inhibited when disk Write Protect notch is present
D	Open	No In-Use Input from the interface pin 16
D1, D2, D4, DDS	Open	No user-installed drive decode
A,B,X	A Jumpered	No head load from Drive Select
C	Open	No Head Load input from the interface pin 18
Y/Z	Z Jumpered	In-Use from Drive Select (not from head load)
DFO	Open	No Non Force Output
TS	Open	No true FM data separation

SA850 Configuration

Here are the Shugart SA850 Jumper settings for use on a CCS 2422, potentially sharing the interface with a PerSci drive.

Jumpers	Setting	Purpose
R-Pack at 5E	Removed (1)	No termination (Assuming termination is in the PerSci drive.)
DS1-DS4	See Below	Drive Select jumper
1B-4B	Open	No Side Select using drive select
RR	Jumper	No radial Ready (jumper disables this option)
RI	Jumper	No radial Index (jumper disables this option)
R	Jumper	-Ready output to interface pin 22
2S	Jumper	"-2-sided disk detected" output to interface pin 6
850/851	850 Jumpered	Soft-sectored disks
I	Jumper	-Index output to interface pin 20
S	Open	No -Sector output to interface pin 24
DC	Open	No -Disk Change output to interface pin 12
HL	Jumper	Stepper power from Head Load & Door Closed (note A,B,X)
DS	Open	No stepper power from Drive Select
WP/NP	WP Jumpered	Write inhibited when disk Write Protect notch is present
D	Open	No In-Use input from the interface pin 16
M	Open	No multimedia option
DL	Open	No door latch option
A,B,X	A Jumpered	No Head load from Drive Select
C	Jumper	-Head Load input from the interface pin 18
Z	Jumper	In-Use from Drive Select
Y	Open	No In-Use from Head Load
S1	Open	No Side Select from Direction Select
S2	Jumper to J1.6	-2-Sided on interface pin 6
S3	Open	No Side Select from Drive Select
TS, FS	FS Jumpered	Standard Data Separator Option
IWI/IWG	IWI Jumpered	Head current switching from interface pin 2
RS/RM	RS Jumpered	Standard Ready signal
HLL	Open	No Head Load Latch
IT	Jumper	In-Use terminator (used as pullup)
HI	Open	No Head Load or In-Use to the In-Use Circuit
F (or FM)	Open	No M2FM encoding
AF/NF (or MFM/ M2FM)	AF (or MFM) Jumpered	Active Read Filter for reading FM and MFM

Notes: (1) If this drive does not have the terminator resistor pack, then install a 150-ohm resistor between pins 1 and 14, and another between pins 5 and 10 at the R-pack location, 5E.

PerSci 277 Configuration

Here are the jumper and optional component settings for a PerSci Model 277 drive (PerSci assembly number 200131-006) in a CCS system. The “Nearest IC” column will help you find the jumpers on a PerSci 277, though these locations may be incorrect for some versions of the PerSci 277. (Note that these settings will actually convert a PerSci Model 270 into a Model 277.)

Jumpers	Nearest IC	Setting	Component	Nearest IC	Value
U11	U11	2-13,4-11	R88	U10	36K
2,4,8,16,32	U16	None	R94	U10	36K
2,4,8,16,32	U27	None	C40	U10	0.1 uF
A,B,C	U17	A-B	C41	U10	0.1 uF
D,E	U17	None	U16		None
F,G	U17	None			
H,J,Z	U4	J-Z			
K,L	U8	K-L			
M,N,P	U3	N-P			
R,S,T	U3	S-T			
U,V	U9	U-V			
W,X,Y	U10	W-X			
AA,AB,AC	U15	AB-AC			
AD,AE,AF	U15	AD-AE			
AH,AJ,AK	U10	AH-AJ			
AL,AM,AN	U1	AM-AN			
AP,AR	U8	APAR			
AS,AT,AY	U3	AS-AT			
AU,AV,AW	U11	AV-AW			
BA,BB,BC	U3	BA-BB			
BD,BE	U7	BD-BE			
BF,BH,BJ	U15	None			
BK,BL,BM	U3	BK-BM			

Additionally, Cut trace to P1-6 (on the solder-side of the Data & Interface board)

PerSci 299B Configuration

Here are the jumper and optional component settings for a PerSci Model 299B drive (With PerSci assembly number 200740 as the main board) in a CCS system. The “Nearest IC” column will help you find the jumpers on a Model 299B, though these locations may be incorrect for some versions of the Model 299B.

Jumpers	Nearest IC	Setting	Component	Value
A1,A2,A3	U6	A2-A3	U2	Omit
A4,A5,A6	U5	A5-A6	U3	Omit
A7,A8,A9,A10	U1	A7-A8 and A9-A10	U22	Omit
B1,B2,B3,B4	U5	None	U23	Omit
B5,B6	U4	B5-B6	U26	75451
B7,B8 (1)		None	U28	(75453)
C1,C2	U16	None		
C3,C4,C5	U16	C3-C4		
C5,C6	U16	C5-C6		
C7,C8	U16	C7-C8		
C9,C10	U16	C9-C10		
C11,C12	U16	C11-C12		
D1,D2	U29	D1-D2		
D3,D4	U29	D3-D4		
D5,D6	U24	D5-D6		
D7,D8	U24	D7-D8		
E1,E2	U11	None		
E3,E4	U11	None		
F1,F2,F3	U50	F2-F3		
G1,G2,G3,G4	U35	None		
H1,H2,H3,H4	U52	H1-H2		
Side 1 Area	U3	C-G		
Side 2 Area	U2	C-G		

(1) Pins B7 and B8 do not exist on the 200740 circuit board. They were introduced in the 200741 board.

How to detect a fast-seeking PerSci drive with the CCS 2422 controller

1. Set the Fast Seek bit low (bit 4 of Control Register 2)
2. Read from the track register (DTRCK) to determine the current track, then write this value to the data register (DDATA), to set up for a null-seek
3. Issue a WD1793 SEEK command with the head unloaded (h=0 and V=0), and wait for the command to complete by monitoring the Interrupt Request bit in Status Register 1.
4. Issue a WD1793 SEEK command with the head loaded (h=1 and V=0), and wait for the command to complete by monitoring the interrupt bit in Status Register 1.
5. Immediately read the WD1793 status register. If the HEAD LOADED bit (bit S5) is set, then the drive is a PerSci drive. If not, then it is a Shugart-type drive.

How it works: Initiating a WD1793 command with h bit (bit 3) transitioning from clear to set causes the WD1793's HLD output to be set. The HEAD LOADED bit in the status register is the logical AND of the HLD output and the HLT input. The HLT input is driven by a 35 mS low-going one-shot (U3b) that is triggered by the rising edge of the HLD output. However, the Seek Complete signal from the PerSci drive forces this one-shot output to be high immediately. Thus, any drive that generates the Seek Complete signal (i.e. a PerSci drive) will cause the HEAD LOADED bit in the Status Register to be high at the end of step 4 above, when it would otherwise have remained low for another 35 mS.

How to perform a fast-seek on a PerSci drive with the CCS 2422 controller

1. Set the Double-Density mode bit high (Bit 6 of Control Register 1), if it is not already high.
2. Set the Fast Seek bit high (Bit 4 of Control Register 2), if it is not already high
3. Issue a WD1793 SEEK command to the target track, with the head loaded (h=1 and V=0)
4. Wait for the INTRQ bit (which is bit 0 in the WD1793 Status Register 1) to be high. (This either means the Seek Complete signal from the disk drive is active or the HLT 1-shot timed out, after approximately 35 mSec.)
5. Loop, waiting for Seek Complete to clear the HLT 1-shot:
 - a. Issue Seek command to same track with the head not loaded (h=0 and V=0), and wait for the command to complete.
 - b. Issue Seek command to same track with h=1 and V=0, and wait for the command to complete (This retriggers the HLT 1-shot.)
 - c. Wait at least 14 μ S, per Western Digital WD179X Application Note, November 1980. (The controller is in double-density mode.)
 - d. Read the WD1793 status register. If the HEAD LOADED bit (bit S5) is 0, then loop to 5a
6. Clear the Double-Density mode bit if it was clear before step 1.
7. Verify that the head is on the correct track using a WD1793 READ ADDRESS command

The loop in step 5 is necessary because the Seek Complete signal from the disk drive is only readable (as the HEAD LOADED bit in the WD1793 status register) when the WD1793 HLD signal is active and the HLT 1-shot has not yet timed out. The low-going pulse on HLD (caused by steps a and b), which creates the HLD positive edge that retriggers the HLT 1-shot, should be short enough that the disk drive head does not actually lift. (~14 μ S)