PerSci and Shugart Drives Together on the CCS 2422

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Background

The CCS 2422 floppy disk controller has two connectors for connecting floppy disk drives. J1 is a 34-pin header for 5.25" disks, and is not discussed here. J2 is a 50-pin header that is intended for either Shugart- or PerSci-type 8" disk drives, with several jumpers to configure it either way.

This paper describes how to configure the controller and the drives and construct an adapter cable, such that both Shugart and PerSci drives can be used together with the CCS 2422 disk controller. It also explains how to detect which type of drive is selected, and how to perform a fast-seek on a PerSci drive.

Note that PerSci changed the interface specification with every new drive they produced, including the Models 70, 270, 277, 299, and 299B. The differences between these PerSci drives require a different adapter cable depending on the particular PerSci drive, unless you make some (gentle) modifications to the drives (particularly the Model 70).

Pinout Comparison

This table shows the pinouts of the CCS 2422 and the various 8" drives, as configured in this document. Pin numbers that end with 'P' are the CCS 2422 PerSci configuration, and those that end with 'S' are the Shugart configuration. Gray cells are disabled options. Red cells are conflicts that must be resolved with the adapter cable. Orange cells: see notes. Purple cells are re-routed with the adapter cable.

CCS 2422 J2			Shugart 800/850		PerSci 70		PerSci 277		PerSci 299B	
Signal	**Dir**	**Pin**	**Signal**	**Dir**	**Signal**	**Dir**	**Signal**	**Dir**	**Signal**	**Dir**
GND		**Odd**	GND		GND		GND		GND	
-TG43	out	**2S**	Write-Current Switch	in	-Motor On (7)	In	Disk Select	in	Side Select	in
Side Select	out	**2P**			N/C (7)					
N/C		**4S**	N/C		N/C		-DS2 right	in	-DS2 right	in
-DS4 (1)	out	**4P**			-DS4 (7)	In				
-2 Sided	In	**6**	-2 Sided	out	N/C		-Ready 1 (4)	out	-Two-Sided	out
-Index (2)	In	**8**	N/C		N/C		-Index 1 (5)	out	-Index 1 (5)	out
-2 Sided	in	**10S**	-2 Sided	out	-Seek Complete	out	-Seek Complete	out	-Seek Complete	
-Seek Complete	in	**10P**								
N/C		**12**	-Disk Change	out	-Restore	in	-Restore	in	-Restore	in
-Eject (8)	out	**12C**								
Side Select	out	**14S**	Side Select	in	-Eject	in	-Eject 0	in	- Eject	in
-Eject	out	**14P**								
-DS3	out	**16S**	-In Use	in	Spindle Pulses (7)	out	-Direct Head Load	in	-Direct Head Load	in
-Head Load (3)	out	**16P**			-Head Load (7)	in				
-DS3	out	**18S**	-Head Load	in	-Head Load (7)	in	-DS2 left	in	-DS2 left	in
-Head Load (3)	out	**18P**			-DS3 (7)	In				
-Index (2)	in	**20**	-Index	out	-Index	out	-Index 0 (5)	out	-Index 0 (5)	out
-Ready	in	**22**	-Ready	out	-Ready	out	-Ready 0 (4)	out	-Ready	out
-Motor On	out	**24**	-Sector	out	-Sep Sector (7)	out	-Motor On	in	SYNC/WCLK	out
			N/C		-Motor On (7)				N/C	
-DS1	out	**26**	-DS1	in	-DS1 left	in	-DS1 left	in	-DS1	in
-DS2	out	**28**	-DS2	in	-DS1 right	in	-DS1 right	in	-DS2	in
-DS3	out	**30**	-DS3	in	-DS3 (7)	in	-Write Prot 1 (6)	out	-Eject Inhibit	in
-DS4 (1)	out	**32**	-DS4	in	-DS4 (7)	in	- Eject 1	in	PLL Clock	out
DIRC	out	**34**	DIRC	in	DIRC	in	DIRC	in	DIRC	in
-Step	out	**36**	-Step	in	-Step	in	-Step	in	-Step	in
-Write Data	out	**38**	-Write Data	in	-Write Data	in	-Write Data	in	-Write Data	in
-Write Gate	out	**40**	-Write Gate	in	-Write Gate	in	-Write Gate	in	-Write Gate	in
-Track 00	in	**42**	-Track 00	out	-Track 00	out	-Track 00	out	-Track 00	out
-Write Prot	in	**44**	-Write Prot	out	-Write Protect	out	-Write Prot 0 (6)	out	-Write Prot	out
-Read Data	in	**46**	-Read Data	out	-Read Data	out	-Read Data	out	-Read Data	out
N/C		**48**	-FM Sep Data	out	-Sep Data	out	-Sep Data	out	-FM Sep Data	out
N/C		**50**	-Sep Clock	out	Sep Clock	out	Sep Clock	out	-Sep Clock	out

(1) As configured, the CCS 2422 drives -DS4 onto both pins 4 and 32
(2) The CCS 2422 always connects pins 8 and 20 (the Index input) together
(3) The CCS 2422 always drives -Head Load onto both pins 16 and 18
(4) As configured, PerSci 277 drives will drive both Ready 0 and Ready 1 to indicate ready
(5) As configured, PerSci drives will drive both Index 0 and Index 1 to indicate Index
(6) As configured, PerSci 277 drives will drive both Write Prot 0 and Write Prot 1 to indicate Write Protect
(7) Fix PerSci 70 pinout: See PerSci Model 70 Modification section below
(8) Requires custom modification to CCS 2422. See below.

PerSci 70 Modification

The PerSci model 70 pinout is substantially different than later PerSci drives. However, a few light modifications will make it reasonably compatible with the 277 and 299B:

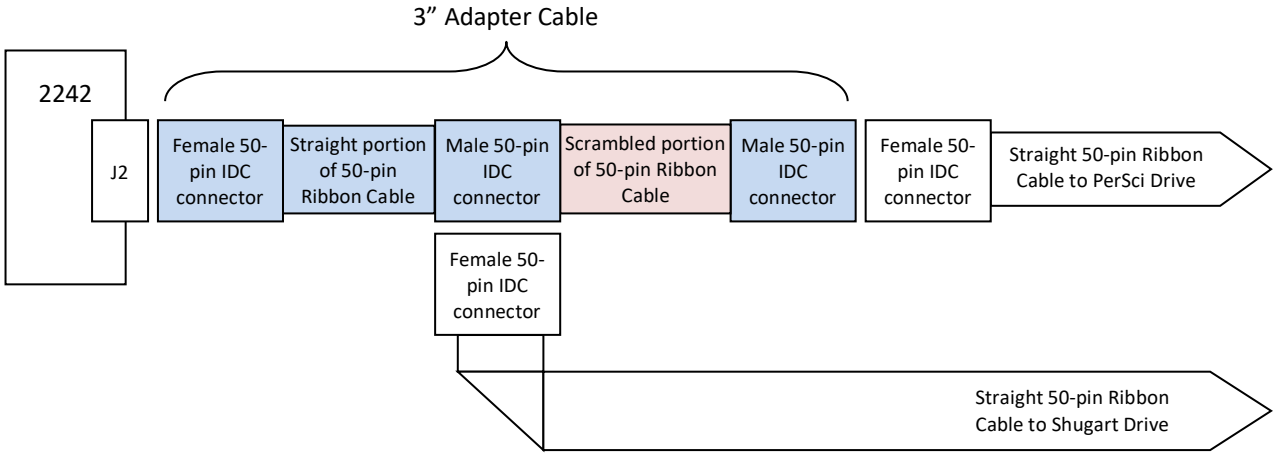
Modification	Result
Soft-Sector setup (SECTOR OPTIONS=1)	P1-24 is no longer driven by -Sep Sector. (U16-3 is still connected to P1-24, but its output is open-collector.)
Cut trace at U56-3 (as found on PerSci Model 70 S/N 402)	P1-16 is no longer driven by Sector Pulses. (U3-3 is still connected to P1-16, but its output is open-collector.)
Remove jumper from H,J,K	Removes -Motor On from P1-2 (Motor on when selected)
Jumper from P1-4 to P1-32	Connects -DS4 also to P1-4. (-DS4 is still on P1-32, but the PerSci adapter cable does not connect to P1-32.)
Jumper from G to F	Head load when drive is selected
Jumper from P1-18 to P1-30	Connects -DS3 to P1-18

This is the resulting Model 70 pinout, compared to the Model 299B for reference:

	PerSci 70		PerSci 299B	
Pin	**Signal**	**Dir**	**Signal**	**Dir**
Odd	GND		GND	
2	N/C		Side Select	in
4	-DS4	In	-DS2 right	in
6	N/C		-Two-Sided	out
8	N/C		-Index	out
10	-Seek Complete	out	-Seek Complete	out
12	-Restore	in	-Restore	in
14	-Eject	in	- Eject	in
16	N/C	in	-Direct Head Load	in
18	-DS3	In	-DS2 left	in
20	-Index	out	-Index	out
22	-Ready	out	-Ready	out
24	N/C		N/C	
26	-DS1	in	-DS1 left	in
28	-DS2	in	-DS1 right	in
30	-DS3	in	N/C	
32	-DS4	in	N/C	
34	DIRC	in	DIRC	in
36	-Step	in	-Step	in
38	-Write Data	in	-Write Data	in
40	-Write Gate	in	-Write Gate	in
42	-Track 00	out	-Track 00	out
44	-Write Protect	out	-Write Protect	out
46	-Read Data	out	-Read Data	out
48	-Sep Data	out	-FM Sep Data	out
50	Sep Clock	out	-Sep Clock	out

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.

Note that with the above modifications to the PerSci model 70 disk drive, the same cable can be used with all 3 PerSci drive types.

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 (1)
5,6	-2SIDED	-2SIDED	5,6 (2)
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)	15,16
17-18	-Head Load	-Head Load	No Connect (1)
19-22	(Unchanged)	(Unchanged)	19-22
23,24	-Motor On	(Ignored)	23,24 (1)
25-28	(unchanged)	(unchanged)	25-28
29,30	-DS3	-DS3	17,18 (1)
31,32	-DS4	-DS4	31,32 (1)
33-50	(unchanged)	(unchanged)	33-50

1. Fix PerSci 70 pinout: See PerSci Model 70 Modification section above
2. Pin 6 of the Persci 277 must be disconnected

CCS 2422 Configuration

Here are the CCS 2422 Disk Controller Board jumper settings. Note that these settings are a mix of the Shugart and PerSci settings in the CCS 2422 manual, plus one additional wire added to the board. With these settings, the interface cable is still compatible with a Shugart SA800 or SA850 disk drive as configured below.

Jumper	Setting	Purpose
A1 through A3	A1-A2	Enable -Head Load onto both pins 16 and 18
B1 through B3	B1-B2-B3	Enable -DS4 onto both pins 4 and 32
C1 through C3	C1-C2	Enable -TG43 onto pin 2
D1 through D3	D2-D3	Enable Side Select onto pin 14
E1 through E3	E2-E3	Enable -Seek Complete from pin 10
FAST SEEK	1-2	Enable software control of Fast Seek
Special Mod	J2 pin 12 - D1	Enable -Eject onto pin 12

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 remain 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 (bit 0 in 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)
   b. Wait at least 6.25 µS and then issue Seek command to same track with h=1 and V=0. (This retriggers the HLT 1-shot.)
   c. Wait 14 µS, per Western Digital WD179X App Note, November 1980. (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 uS)

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,B Jumpered	Head loads if both -Head Load and drive selected
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, S2, S3	S2	Standard -Side Select from J1-14
2S	Jumper to J1.6	-2-Sided on interface pin 6
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 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.

Jumpers	Nearest IC	Setting
U11	U11	2-13,4-11
2,4,8,16,32	U16	None
2,4,8,16,32	U27	None
A,B,C	U17	A-B
D,E	U17	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	AL-AM
AP,AR	U8	AP-AR
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

Component	Nearest IC	Value
R88	U10	36K
R94	U10	36K
C40	U10	0.1 uF
C41	U10	0.1 uF
U16		None

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

PerSci 299/299B Configuration

Here are the jumper and optional component settings for a PerSci 299/299B drive (With PerSci assembly number 200740 or 200741 as the main board) in a CCS system. The "Nearest IC" column will help you find the jumpers on a PerSci 299B, though these locations may be incorrect for some versions of the PerSci 299/299B.

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	75453
B7,B8 (1)		None	U28	(75453)
C1-C2	U16	None for drives 0&1, jC1-C2for drives 2&3		
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 for drives 0&1, None for drive 2&3		
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.