SSD - Floppy Disk Operation

Technical Note

Reference No. TN7823-000 Issue 0-0D

23rd August 2019

Contents

Review Record

Issue	Date	Section	Changes made	By
0-0a	09-FEB-2019		Initial draft	JHG
0.0b	28-JAN-2019	2.0	Added section	JHG
0.0c	09-FEB-2019	2.0	Updated section	JHG
		5.0	Added Emulation Requirements	JHG

1.0 Introduction

This document is a brief description of how a real floppy disc works & how it differs from the FLOPPYFLASH-2 (FF2)

For a more detailed knowledge there are a number of manuals, which may be read in conjunction with this document:

Ref. 1

The floppy user guide

June 11th, 2001

Ref .2

The data sheet No.’s and revisions stated were the latest when this document was written.

2.0 Disk Drive Overview

A floppy disc drive (FDD) is fairly simple system. It is made up of only a few functional blocks:

2.1 Spindle motor

This is a motor that is enabled when the **MOTOR_ON** signal is asserted & then spins at a constant speed (normally 300rpm & 360rpm) and only in one direction.

2.2 Read/write head

This is a magnetic head which can read or write pulses to the disc surface. In cannot do both at the same time, so when the head needs to write the **WRITE_GATE** signal is asserted & the **WRITE_DATA** signal determines the duration & frequency.

An FDD will has 1 or 2 heads. If the drive is equipped with 2 heads then the 2nd head is selected with the **SIDE_SELECT** signal.

2.3 Stepper Motor

The heads are able to be moved from the outside edge towards the centre in a series of steps. Each pulse on the **STEP** signal induces a step. The direction of the step is determined by the **DIR** signal. Each step position determines the location of each track on the disk.

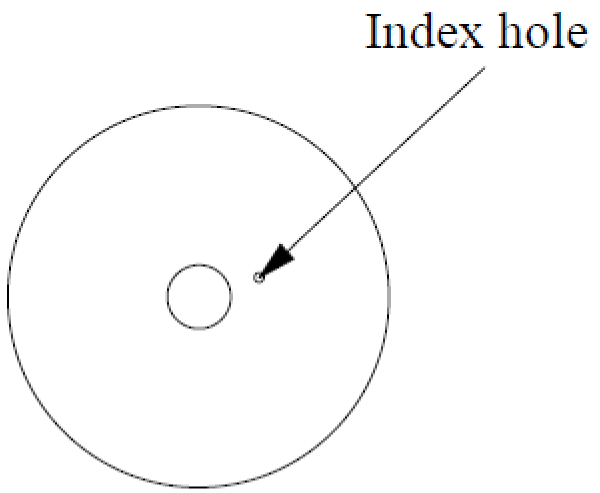
The drive has a predetermined number of steps which defines the number of tracks it can support.

2.4 Motor Enable

To start the motor spinning, there is a **MOTOR_ON** signal for the host to assert.

2.5 Index marker

As the diskette spins, there is a hole to indicate a complete revolution. Each time it passes a sensor in the drive, it asserts the **INDEX** single. This allows the host to ascertain the diskette is actually spinning, & allow with it to synchronise to the start on the track.



2.6 Drive Select

A single Shugart bus can allow more than one drive to be connected at any one time & share all the signals. This enables the host to choose which drive it wishes to communicate with. There are up to 4 drive select signal; **DS1-4**. This allows 4 drives to co-exist on the bus as only 1 drive select signal as asserted at any one time.

2.7 Write Protect

Each diskette has the ability to be write protected. This is in the form of a hole/notch in the disk sleeve which, when covered, the drive detects & prevent the diskette being written to.

2.8 Disk Ready

When a disk is present in the drive, the **READY** signal is asserted when the drive is selected. This allows the host to know a diskette is present & ready for use.

2.9 Disk Change

Then the drive is selected for the 1st time, either from power-up, or after a disk have been changed, the when a disk is present in the drive **DISK_CHANGE** signal is asserted for a short period on time so the host knows it may be a different disk.

2.10 Data capacity limits

There is a limit to the amount of data as can be stored on a diskette. This is governed by both the drive & the diskette.

The drive has a number of mechanical:

1. Number of sides (heads)
2. Number of tracks (Steps)
3. Number data bits

Items 1 & 2 above were covered earlier.

The number of data bits is limited by the speed that read/write heads can respond & how close together the data bits can be physically located on the diskette.

This is defined as data density, which is usually represented as bits/inch (bpi) & determines how many bell cells can be stored.

3.0 Disk Format Overview

In order for the host to store data on the data, in needs to understand the encoding method & how the data to structured & navigated to.

This is known as **low level formatting** & this is where the diskette's become host specific & no longer determined by any one drive manufacturer. There are many drive manufacturers which make drive to the same specification &, unlike intelligent drives (e.g. SCSI) the host is unable to interrogate the make & model of the drive in use.

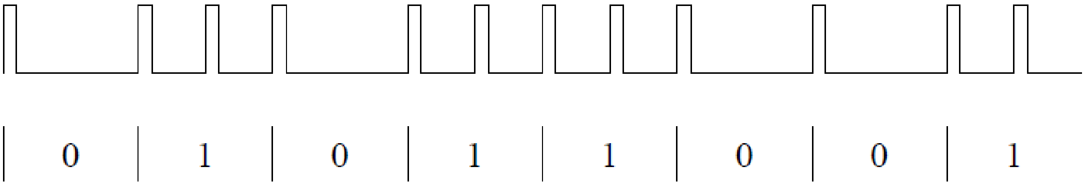
3.1 Data Encoding

Shugart define a number of bit stream encoding standard, but really only two are adopted;

3.1.1 FM

FM (frequency modulation), also known as single density, is the simpler of the two, but needs to bit cells for each data bit.

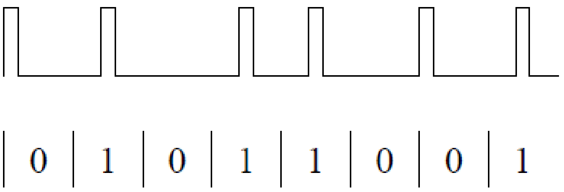
Each data bit requires a clock bit cell & data bit cell. The clock bit cell synchronises the host to allow it read the data bit cell correctly.



3.1.2 MFM

MFM (modified frequency modulation), also known as double density, is more complex than FM. However, it only needs one bit cell for each data bit.

Each data bit is encoded by the position within the bit cell itself. If the data is at the start of the cell it represents a '0' & it the data is in the centre of the cell that represents a '1'. There is an exception to the rule where no data exists in the bit cell when a '0' need to follow a '1' to ensure data density is not exceeded.



3.2 Low Level Format

In order for the data on the diskette to be easily managed by the host, it needs to be split in to manageable chunks. Due to the mechanics of the drive, there are already two dimensions to this; tracks & sides. Both of which are determined by the drive itself (see 2.0 Disk Drive Overview).

However, this is usually split up even more. This is known as **low level formatting** & this is where the diskette's become host specific.

Each track is usually split in to multiple sections & these are called **sectors**. Each sector needs identification information, so the host knows where it is on the diskette for navigation purposes. Each sector also includes a data integrity checks to ensure the data is correct when read.

Furthermore, due to the way the drives work, the sectors also need slippage. This is because a disks cannot reliably spin at exactly the same speed constantly & when moved from drive to drive.

Typically sectors constructed like this:

INDEX			
GAP	PREAMBLE	SYNC	MARK

HEADER #1						DATA #1					
GAP	PREAMBLE	SYNC	MARK	HEADER	CRC	GAP	PREAMBLE	SYNC	MARK	DATA	CRC

HEADER #2						DATA #2					
GAP	PREAMBLE	SYNC	MARK	HEADER	CRC	GAP	PREAMBLE	SYNC	MARK	DATA	CRC

.

.

HEADER #n						DATA #n					
GAP	PREAMBLE	SYNC	MARK	HEADER	CRC	GAP	PREAMBLE	SYNC	MARK	DATA	CRC

SECTOR
GAP

3.2.1 Gap

There's a number bytes gap to ensure deviations with hosts, drives & disks speeds are accommodated so when individual sectors are re-written, they do not overlap the following sector.

3.2.2 Sync

To ensure the bit stream is byte aligned, there is a synchronisation pattern that the host looks for so it knows which bit is the 1st bit in the byte. There may be more than one sync byte.

3.2.3 Mark

Used to identify the field; INDEX / HEADER / DATA.

3.2.4 Header

This is the sector identification field. It is used by the host, in normal read/write operations, to identify the location of the data on the disc. Is contains information:

HEADER			
CYLINDER #	SIDE #	SECTOR #	LENGTH

3.2.4.1 Cylinder

Cylinder (or track) number.

3.2.4.2 Side

Side number. This is normally 1(0) or 2(1) but could be used for virtual sides to increase the number of sectors beyond 255. This extension is also used for floppy tapes.

3.2.4.3 Sector

Sector number. This is the sector on a given track / side.

3.2.4.4 Length

This defines the length of the follow data section. log2(length of user data field)−7.

E.g. 0 = 2^7 (128 bytes); 1 = 2^8 (256 bytes); 2 = 2^9 (512 bytes)

3.3 Data

This field is where the actual data for the host is stored. It is a contiguous block of the header defined length.

3.4 CRC

For data integrity checks there is a 16-bit cyclic redundancy check (CRC) word for the preceding bytes up to & including the Synchronising filed.

4.0 FLOPPFLASH-2 Topology

The implementation of the FLOPPYFLASH-2 (FF2) focuses on the storage of the data on the CF card & not the rest. This means in order for the FF2 to separate out the data, it needs to know how the low level formatting it done. This is the fundamental difference between the FF2 & a real drive.

So, because the host defines the low level formatting, the FF2 must define the host in order for the emulation to work correctly. This is why the emulations on the FF2 detail the host and not the drive.

5.0 Emulation requirements

There are some basic information required to assist in creating an emulation. These are in two categories:

5.1 Drive parameters

1. Drive make / model (ideally a unit should be supplied).
2. Spindle speed (RPM).
3. Heads (or sides) per disk (count).
4. Tracks (or Cylinders) per head (count).

5.2 Host parameters

1. Host make / model & operating system details (ideally a unit should be supplied)
2. Encoding method (FM/MFM).
3. Bit rate (Hz or uS).
4. Sectors per track (count).
5. Bytes per sector (count).

5.3 Emulation process

This process starts with the above information which allows the identification of an existing emulation which may satisfy the requirements. To evaluate this, the above parameters are required (see sections 5.1 & 5.2)

If an existing emulation does not match, or the parameters cannot be supplied, then access to a functional drive & disk (and possibly a host) will be required as traces will need to be taken. Ideally this should be supplied to SSD to avoid the expense of site visits as this may take several days.

If a drive & disk cannot be supplied then access needs to be granted to a functional host with the required drive & disk operational. The host should be made available for 1-2days (possibly more depending on the uniqueness of the host/drive/disk/formatting)

Please note that some customers have security issues which do not allow access to the host, or restrict who can have access & what equipment can be used / connected to the host. Also some customers may not allow information, such as traces, disk images etc, to be removed from site.

Finally if access cannot be granted, then the only option left is to hire a matching system.

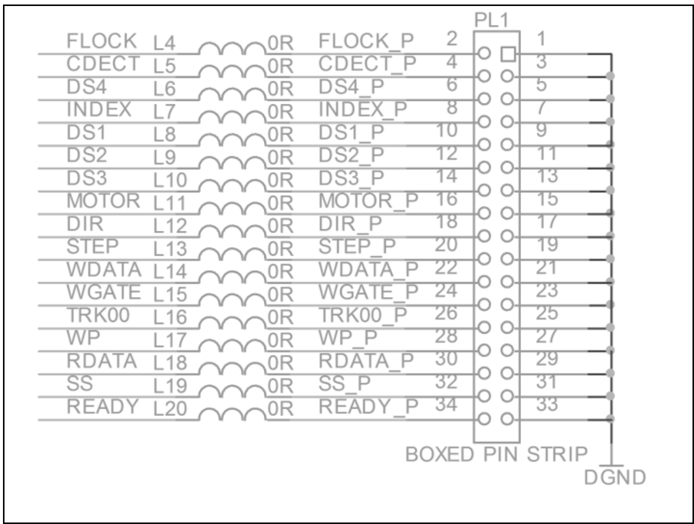
Without any of the above, it is unlikely an emulation can be created.

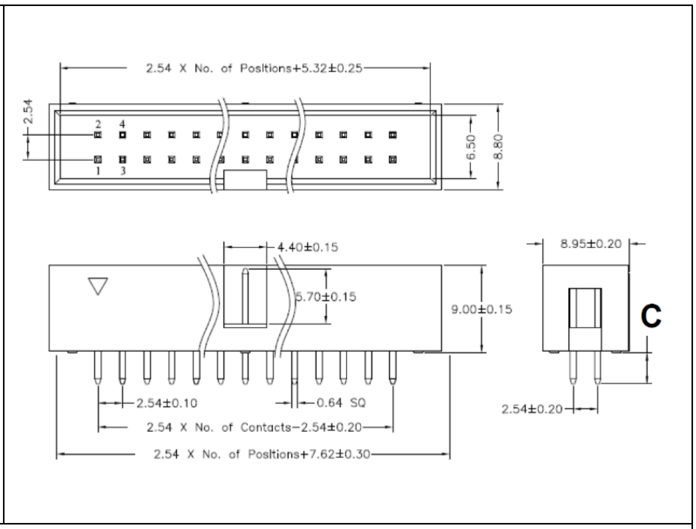
6.0 Host Interfaces

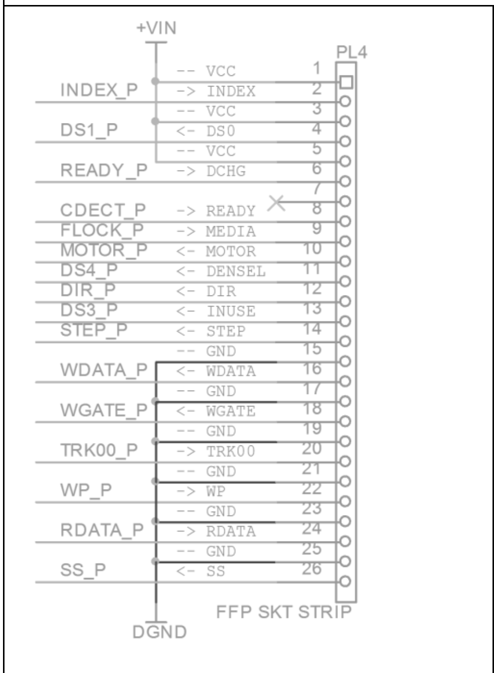
Different build options allow for different requirements.

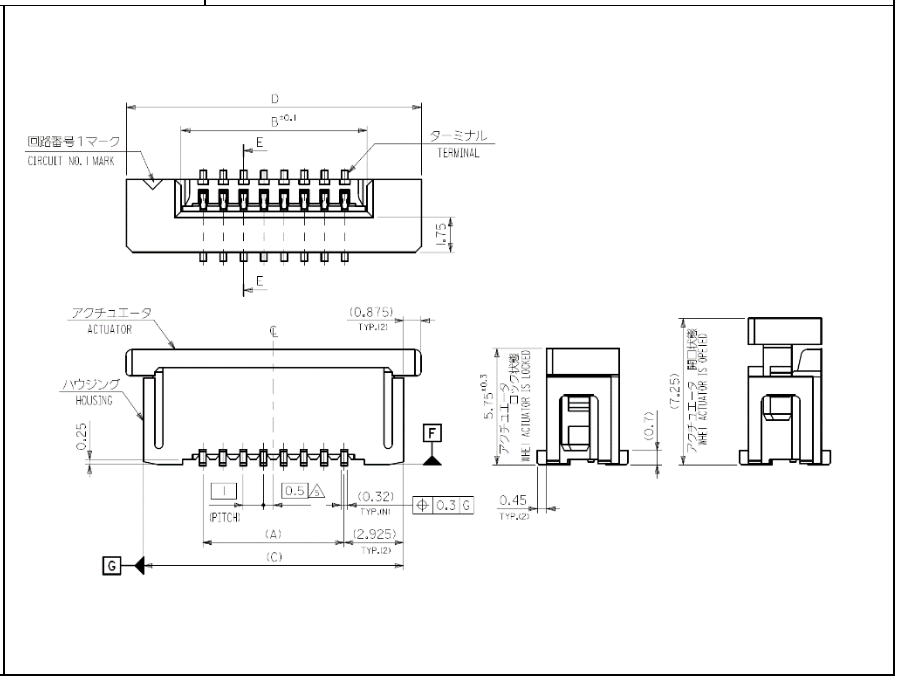
6.1 Signal Interface

Currently the FF1 supports a generic 34 pin IDC polarized boxed header. This will interface directly with the standard PC 3½" floppy drive. Here is also a build option to support the FD1238T.



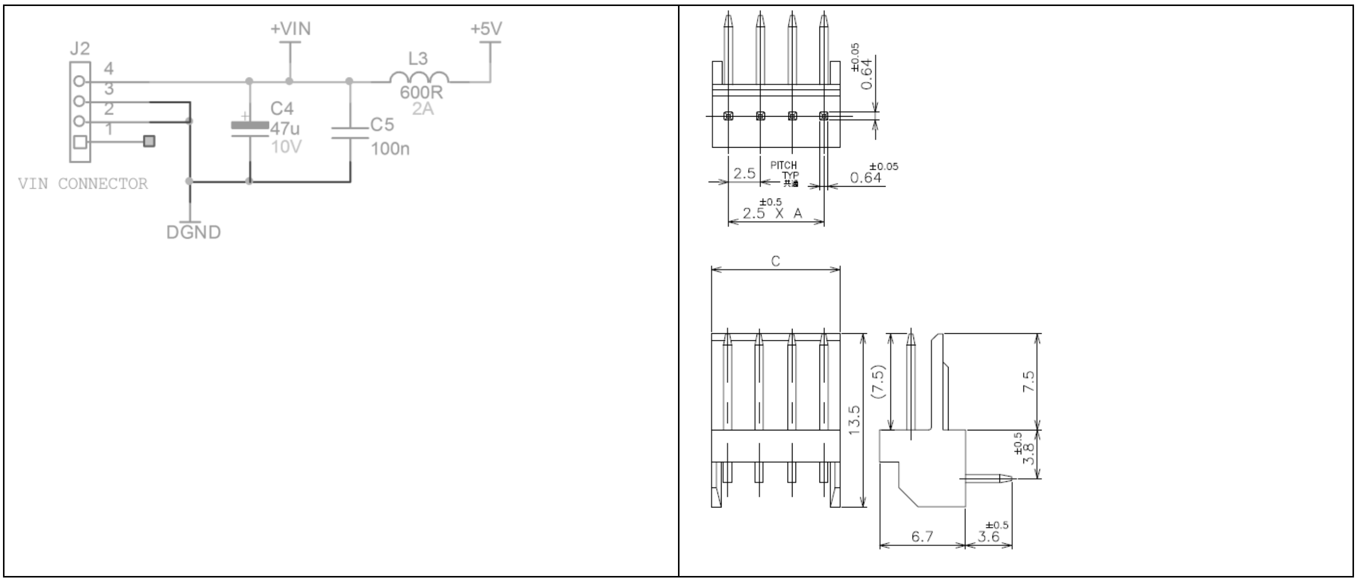






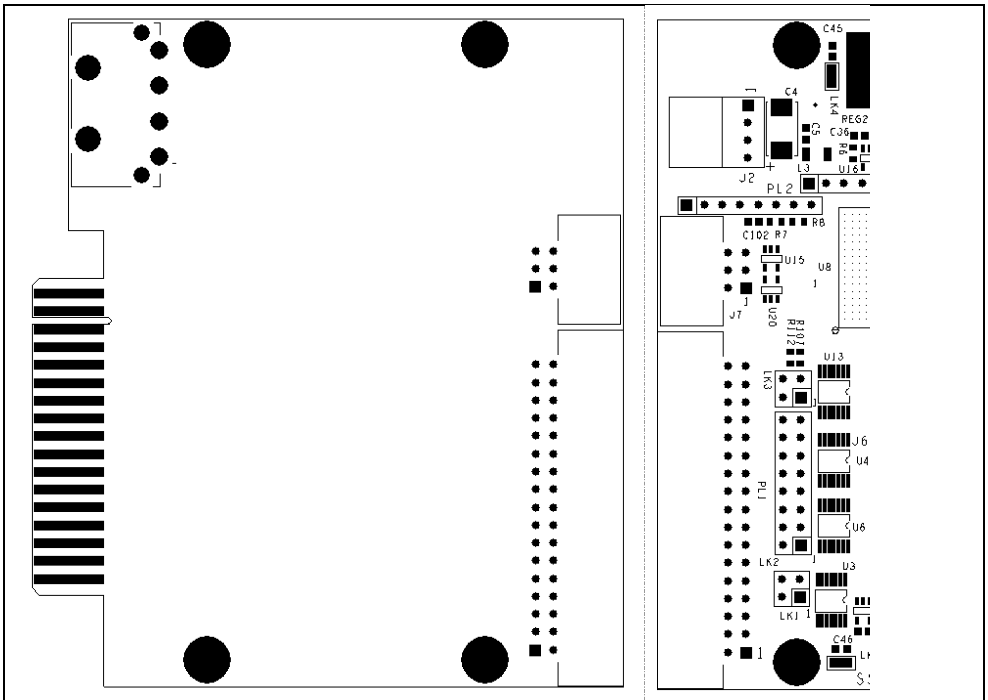
6.2 Power Interface

There is the standard 3½" floppy power connector.



6.3 Expansion Interface

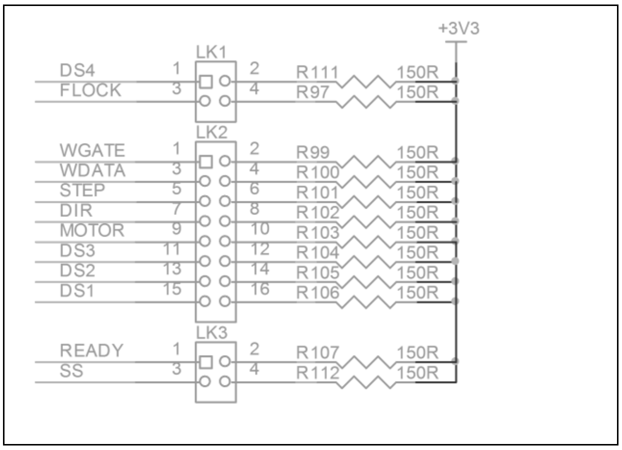
For future interface there is an additional power connector which is the same type as the 3½" signal connector, but only 6 way. This will allow extension boards to be made with alternative interfaces yet to be required without the need of a complete new board. (E.g. for the 5¼" floppy & possible QIC support)



Example 5 ¼" Floppy interface **FF-1**

6.4 Termination

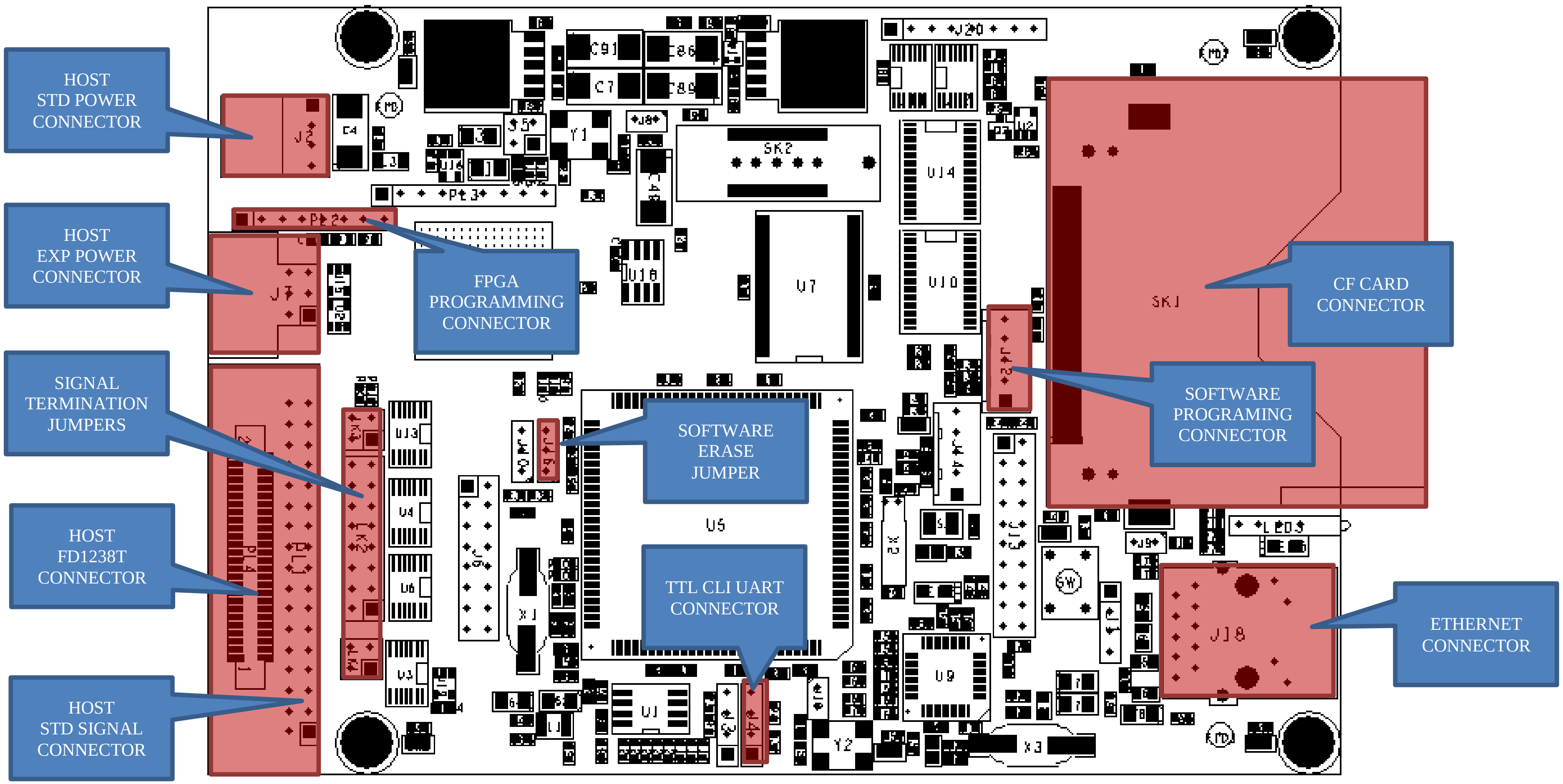
As part of the Shugart specification, the signal lines need to be terminated. This may be different for future interfaces, so the current design has these as optional links on the input signals.



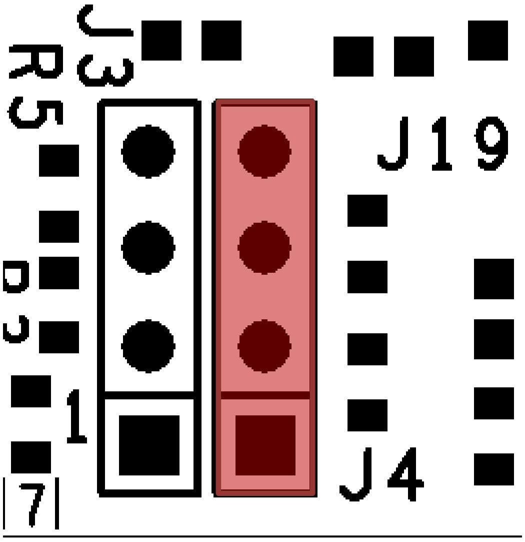
For current operation the following links should be fitted.

LK	PIN	SIGNAL	STD	DACS4
LK1	1-2	DS4	X	X
	3-4	FLOCK	X	
LK2	1-2	WGATE	X	X
	3-4	WDATA	X	X
	5-6	STEP	X	X
	7-8	DIR	X	X
	9-10	MOTOR	X	X
	11-12	DS3	X	X
	13-14	DS2	X	X
	15-16	DS1	X	X
LK3	1-2	READY	X	
	3-4	SS	X	X

7.0 Configuration



7.1 TTL CLI UART Connector



J4

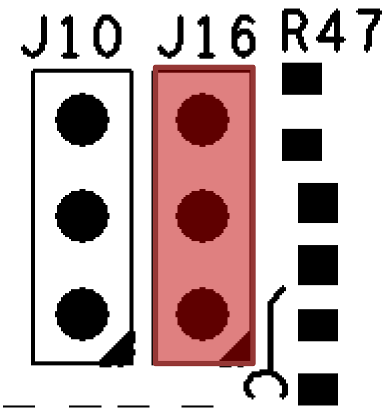
4 - GND

3 - TXD

2 - RXD

1 - +3V3

7.2 Software Erase Jumper



J16

3 - NORMAL

2 - COM

1 - ERASE

Fit J16 pin 2-3 for normal operation. Fit 1-2 to erase software.

8.0 Commands

The current CLI command set is very simple & is a subset of the SF2

8.1 VER

Displays software, revision, firmware revision, Hardware ID, Controller ID & revision and software compilation date/time.

Syntax: VER

```
>ver

FloppyFlash1_Ethernet Version E01.002.2

Copyright Solid State Disks Ltd
www.ssd.gb.com

Serial Number: 3381
Hardware ID = 11-02
Controller ID = 7823 00.10
Emulation Ref 1000      GENERIC PC FDD-HD 3.5"
-- Compiled: Jan 15 2017 12:03:56 --
```

8.2 LIST

Displays a list of the supported emulated devices.

Syntax: LIST

List all emulations.

```
>list

Device ID  Block     Size   Type     Manufact   Model Number
     1000    512  1.44 MB    RD       GENERIC   PC FDD-HD 3.5"
     1001    512  1.44 MB    RD       GENERIC   OS9 FDD-HD 3.5"
     1002    256   720 KB    RD       GENERIC   OS9 FDD-DD 3.5"
     2000    512    26 MB    TP       WANGTEK   FAD5000
     2001    512    26 MB    TP        CIPHER   525 FloppyTape
```

Syntax: LIST RD

List all removable Drives.

```
>list rd


Device ID  Block      Size   Type     Manufact    Model Number
     1000    512   1.44 MB     RD      GENERIC    PC FDD-HD 3.5"
     1001    512   1.44 MB     RD      GENERIC    OS9 FDD-HD 3.5"
     1002    256    720 KB     RD      GENERIC    OS9 FDD-DD 3.5"
```

Syntax: LIST TP

List all tape drives.

```
>list tp


Device ID  Block      Size   Type     Manufact    Model Number
     2000    512     26 MB     TP      WANGTEK    FAD5000
     2001    512     26 MB     TP       CIPHER    525 FloppyTape
```

Syntax: LIST <manufacture>

List all emulations by the named manufacturer

```
>list cipher


Device ID  Block      Size   Type     Manufact    Model Number
     2001    512     26 MB     TP       CIPHER    525 FloppyTape
```

Syntax: LIST DETAILS

List details of the current emulation

```
>list details


GENERIC PC FDD-HD 3.5"
       Device ID code 1000
          Device Type RD
           Block Size 512
      Native Capacity 00000B40
        Controller ID 7823 00.07
```

Syntax: LIST EXT

List all emulations with extended information

```
>list ext

Device ID  Block     Size   Type     Manufact   Model Number                              Controller ID
     1000    512  1.44 MB     RD      GENERIC   PC FDD-HD 3.5"                            7823 00.07
     1001    512  1.44 MB     RD      GENERIC   OS9 FDD-HD 3.5"                           7823 00.08
     1002    256   720 KB     RD      GENERIC   OS9 FDD-DD 3.5"                           7823 00.09
     2000    512    26 MB     TP      WANGTEK   FAD5000                                   7823 00.07
     2001    512    26 MB     TP       CIPHER   525 FloppyTape                            7823 00.07
```

The **Controller ID** displayed is the controller version & minimum revision that the emulation requires.

8.3 SETDEV

Set the device to be emulated & is stored in non-volatile memory for the device selection is reinstated following a power cycle.

Syntax: SETDEV <deviceID>

```
>setdev 1000

Emulation Ref 1000      GENERIC PC FDD-HD 3.5"
```

On selection the system is checked for a compatible Controller version & revision.

If the hardware platform cannot support the selected device emulation, an error message is displayed & the system revert back to the current selection.

```
>setdev 2001

Device Id 2001 is not support on current hardware
Emulation Ref 1000      GENERIC PC FDD-HD 3.5"
```

8.4 ONLINE / OFFLINE

Change device online / offline state.

When the device is offline the FF1 signals to the host that there is no media fitted.

When the device is online & there is media installed, the device will operate normally.

Syntax: ONLINE

Syntax: OFFLINE

Note that the device can take up to 10 seconds to go offline (idle timer). This is to ensure the host has had sufficient time to write/read all the device associated with the current operation.

8.5 ERASE

Erase CF card. Note that that command may take many minutes to complete which is dependent on the size of the capacity selected.

Syntax: ERASE MEDIA

Erase the entire CF card capacity

Syntax: ERASE DEVICE

Erase the device capacity as defined by the emulated device.

```
>erase device


>
do Fill Data Pattern
 Sector Address    0
 Number of Sectors B40, 2880d
 Fill Type:        All bytes FF


 0%
 1%
 2%
 3%
 4%
 5%
 6%
 7%
 8%
 9%
 10%
 11%
Fill complete
```

8.6 WPROTECT

Turns the drive write protection on / off. Note that this is currently only associated with the drive & not the CF card. It is also not retained in non-volatile memory so with not be restored following a power cycle.

Syntax: WPROTECT ON

Enable drive write protection mode.

Syntax: WPROTECT OFF

Disable drive write protection mode.

8.7 SETETH

Used to manager the Ethernet connection settings.

Syntax: SETETH

Displays current Ethernet connection settings. This is retained in non-volatile memory & is restored following a power cycle.

```
>seteth

Current settings: IP Address        192.168.1.46
                  Listen port       1024
                  MAC Address       11:22:33:44:55:66
```

Syntax: SETETH IP <ip address >

Set Ethernet IP address in the form of 4 decimal number from 0-255 separated by dot (.).

```
>seteth ip 192.168.1.46

Current settings: IP Address        192.168.1.46
                  Listen port       1024
                  MAC Address       11:22:33:44:55:66
```

Syntax: SETETH PORT <port number>

Set Ethernet port number in the form of a signal decimal number from 0-65535.

```
>seteth port 1024

Current settings: IP Address        192.168.1.46
                  Listen port       1024
                  MAC Address       11:22:33:44:55:66
```

9.0 Production Setup

During production there are a number of items which need to be setup. In order to make these settings, the board must be programmed with the **FactorBuild** firmware.

```
>ver

FloppyFlash1_FactoryBuild Version F01.002.2

Copyright Solid State Disks Ltd
www.ssd.gb.com

Serial Number: 18446744073709551615
Hardware ID = 11-03
Controller ID = 7823 00.10
Emulation Ref 1000      GENERIC PC FDD-HD 3.5"
-- Compiled: Jan 16 2017 08:58:26 --
```

(NB: The serial number of an unprogrammed unit will be many characters & may vary.)

Once both the Serial Number & the Ethernet MAC address are programmed the unit must be power cycled. Then run the **VER** & **SETETH** commands to ensure the serial number & MAC address are correct.

Now the unit must be erased & reprogrammed with the required release firmware.

THE UNIT MUST NOT BE SHIPPED WITH THE FACTORBUILD FIRMWARE.

9.1 Serial Number

Each board manufactured is labeled with a unique serial number & barcode. This is located by the CF card socket (SK1)


```
>setserial 4266

Current Serial Number: 4266
```

9.2 Ethernet MAC Address

For Ethernet builds each unit must be equipped with a unique MAC address as supplied by the IEEE governing body. A record of the MAC address allocation must maintained along with the associated serial number.

```
>seteth mac 11:33:55:77:99:aa

Current settings: IP Address          192.168.1.44
                  Listen port         1024
                  MAC Address         11:33:55:77:99:aa
```

N.B. The IP Address & Listen Port numbers will default to the above in unprogrammed units.

End.