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F i x e d D i s k D r i v e

S l i m - l i n e

S P E C I F I C A T I O N

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1. INTRODUCTION

1.1 GENERAL DESCRIPTION

The BASF 6188 stores the information on up to 2 non-removable disks and up to 360 cylinders.

The BASF 6188 uses the industry standard interface and dimensions to ease system integration. Up to four BASF 6188 may be connected to one controller. For systems requiring removable media it is recommended to use the BASF 6188 in combination with BASF Mini Floppy Disk Drives which offer a capacity of up to 1 MByte.

The use of proven and highly reliable Winchester-Technology disks and heads together with a closed-loop air filtering system guarantees a maintenance-free operation throughout the drive's lifetime and results in a MTBF of 11,000 working hours.

Reliability and low costs are the result of mechanical simplicity and drive ruggedness, containing such features as a highly increased lifetime of the steel band actuator, and a built in shock absorber system.

Summary of main features:

- Storage capacity up to 15 megabytes unformatted
- Highly reliable Winchester-Technology
- Steel band actuator and fast access stepper motor
- Directly driven spindle with brushless DC-motor
- Integrated shock absorber system
- Spindle brake for reduction of stop time
- Industry standard interface and dimensions
- Microprocessor control
- Ramp mode

1.2 SPECIFICATIONS

1.2.1 PERFORMANCE SPECIFICATIONS

Model BASF 6188

Disks 2
Cylinders 360

Capacity unformatted

Per drive (MBytes) 15
Per surface (MBytes) 3.75
Per track (KBytes) 10.4

Capacity formatted

Per drive (MBytes)	11.8	(13.3)
Per surface (MBytes)	2.9	(3.3)
Per track (KBytes)	8.2	(9.2)
Per sector (Bytes)	256	(1024)
Sector per track	32	(9)

Transfer rate (Mbits/sec) 5

Access Times (includes settling time)

	Single Step Mode	Buffered Step Mode (Ramped)
Step Pulse Rate	1.0 msec - 3.1 msec	10 us - 200 us
Single track	15 msec	15 msec
Average * (360 cyl)	135 ms	88 ms
(306 cyl)	117 ms	78 ms
Maximum (360 cyl)	374 ms	213 ms
(306 cyl)	320 ms	186 ms

* (equals 1/3 full-stroke)

Average latency (msec) 8.3
Head settling time (msec) 15
Start-up time (sec) 24
Stop time (sec) 10

1.2.2 FUNCTIONAL SPECIFICATIONS

Model	BASF 6188
Rotational speed (rpm)	3600 \pm 1%
Recording density (bpi)	8900
Flux density (fci)	8900
Track density (tpi)	406
Index (per rev.)	1
Encoding method	MFM

1.2.3 RELIABILITY SPECIFICATIONS

Mean Time Between Failure (MTBF)	11,000 hours*
Mean Time To Repair (MTTR)	30 minutes
Preventive Maintenance (PM)	none required
Designed Lifetime	5 years

Error rates

Soft read errors	1 per 10^{10} bits read
Hard read errors	1 per 10^{12} bits read
Seek errors	1 per 10^6 seeks

Note: * Power On time under typical usage

Disk Media Defects

Disk drives are allowed to have the following number of media defects when leaving the factory:

BASF 6188 10 max. but not more than 5 per surface

Cylinder zero is delivered error free.

1.2.4 PHYSICAL SPECIFICATIONS

DC-Power requirements (measured at BASF 6188 DC power connector J3)

Operating Mode	+12V \pm 10%	+5V \pm 5%
Start up	2.5 A	1 A
Positioning	1.4 A	0.9 A
Data Transfer or Wait	1.1 A	0.8 A

Noise 50 mV peak to peak max.*
 Heat dissipation 17 Watts typ.
 during data transfer or Wait

Mechanical dimensions

Height	40.64 mm (1.6 inches)
Width	146 mm (5.75 inches)
Depth **	203 mm (8 inches)
Weight	1.4 kg (3.1 lbs)

Safety requirements: in accordance with UL

Notes: * No combination of ripple and noise shall exceed the supply tolerances.

** Face plate not included

Mounting orientation:

The BASF 6188 may be operated only when the Face Plate is in a vertical plane. The maximum deviation is an angle of 13 degrees. From the remaining four possible orientations only three are allowed for operation. These are with the Read-Write-Control PCB either on the left or right side or at the bottom of the drive. Operation with the Read-Write-Control PCB on the top of the drive is not allowed.

1.2.5 ENVIRONMENTAL SPECIFICATIONS

1.2.5.1 OPERATING

The BASF 6188 shall work as specified when operated under the following environmental conditions:

Temperature	4 to 50 degr. C
Temperature gradient	15 degr/h max.
Relative humidity	15 to 80% (no condensation)
Dew point temperature	25 degr. C
Atmospheric pressure	84 to 110 x 10 ⁺³ N/m ² (-300 m to 3000 m)
Vibration: 5 to 50 Hz:	0.075 mm peak displacement
50 to 500 Hz:	1.0 g accel. (all directions)

Shock: Impact shocks of up to 3 g acceleration and up to 11 msec duration at least 10 sec apart.

Purity of surrounding air: Normal office conditions

1.2.5.2 STORAGE AND TRANSPORT (without packaging)

The BASF 6188 shall not show any damages or defects when the following conditions are met during shipment and storage.

Temperature	-40 to +70 degr. C
Temperature gradient	20 degr/h
Relative humidity	5 to 95% (no condensation)
Altitude range	-300 m to 14000 m
Single shock	max. 50 g acceleration
Periodical shocks	max. 5 g acceleration

During transportation and storage the heads should be positioned at the innermost cylinder.

The drive has a unique feature which after power loss detection moves the heads to the innermost tracks where they are locked through the Stepper motor lock solenoid.

2. FUNCTIONAL CHARACTERISTICS

2.1 BASIC FUNCTIONAL UNITS

2.1.1 DRIVE MECHANISM

A "disk pack" consisting of a hub with 2 disks is mounted on a spindle which is directly rotated at 3600 rpm by a brushless 12 VDC motor. The motor current is commutated by Hall Sensors and related control electronics. This circuit also generates the Index pulse.

2.1.2 HOUSING

The sealed module consists of an aluminium molded chassis and cover. A closed loop air filtering system inside constantly cleans the air of particles which may be generated by head to disk interaction. An absolute breather filter for pressure equalization with the ambient air pressure protects against environmental contamination.

2.1.3 POSITIONING

The carriage on which the read/write heads are mounted is driven by a stepper motor via a capstan and a metal band. The carriage itself is precision mounted and guided by ball bearings.

2.1.4 DISKS

The disks are "Winchester" type and have an outside diameter of 130 mm and an inner hole diameter of 40 mm. They are coated with a thin layer of magnetic oxide on an aluminium substrate and are additionally lubricated for head wear protection during incontact start and stop operation.

2.1.5 BRAKE

For further protection of heads and disks in applications where the system is switched on and off very often a mechanical brake is installed to reduce the stop time to 10 sec.

2.1.6 READ/WRITE HEADS

Heads are "Winchester" type with minor modifications for track width and flying height adjustment with respect to a different relative head to disk velocity.

2.1.7 CONTROL ELECTRONICS

Control and read/write electronics are packaged together on a single printed circuit board while power electronics for both Spindle and Stepper Motor are located on a separate small printed circuit board.

The control electronics fulfills the following functions:

- Drive Selection (one out of four) and indication
- Permanent Spindle Motor speed check
- Index generation
- Stepper Motor Control including velocity ramp and hysteresis elimination
- Track Zero detection
- DC Voltage monitoring
- Automatic retrack to shipping position after power down
- Microprocessor control of interface lines
- Error detection and display on front panel

2.1.8 READ/WRITE ELECTRONICS

Besides the usual read and write function the Read/Write electronics performs error detection such as write fault and selection of multiple heads during reading and writing.

2.2 FUNCTIONAL OPERATION

2.2.1 SPINDLE MOTOR START

The spindle motor of the BASF 6188 may be started in two ways: either by applying the DC-voltages to the drive or through the interface DR SEL (Drive Select) signal. This feature allows sequential start up in case several drives are connected to the system in order to reduce start up current.

2.2.2 DRIVE SELECTION

Each drive is assigned an address by setting the corresponding Drive Select switch on the drive. Drive selection is done by activating the corresponding DR SEL (Drive Select) signal through the control unit. The selected drive responds then to all input signals and enables its output drivers. In addition the green front panel LED will be activated.

Alternatively the drive may be permanently selected through an option switch if only one drive is connected to the controller. However, the green front panel light will only be on when one of the Drive Select lines is activated.

2.2.3 Recalibrate / Restore

After Power On the drive's positioning system is recalibrated by performing an automatic seek to Track Zero.

2.2.4 SEEK

In order to reach data on a specific track the controller has to position the heads to that track by providing or receiving the following information after drive selection:

- check that WRT GATE (Write Gate) is inactive
- check that READY is active
- select the desired direction
- provide STEP pulses
- wait for SEEK COMPL (Seek Complete) active

Each STEP pulse causes a head movement by one track. The head movement is initiated by the trailing edge on the pulse. The BASF 6188 has two possibilities of step functions:

- single step mode
- buffered step mode

2.2.5 HEAD SELECTION

Each one of the four heads is selected by applying the binary head address to the three HD SEL (Head Select) lines.

2.2.6 WRITE OPERATIONS

To perform a write operation, the appropriate track and head must be accessed and WRT FLT (Write Fault) must be inactive. Writing is then accomplished by activation WRT GATE (Write Gate) and transmitting data on the MFM WRT DATA (MFM Write Data) lines.

2.2.7 READ OPERATION

The drive is always in read mode when WRT GATE (Write Gate) is inactive. For reading it is only necessary to access the appropriate track and head.

2.3 USER SELECTABLE OPTIONS

The BASF 6188 has 7 switches for the selection of different options:

Four switches (1-4) are used to set the drive address. Drive selection is performed when the DR SEL (Drive Select) signal corresponding to the switch setting is active.

Switch 5 allows to select a drive permanently and independent of the state of the DR SEL (Drive Select) signals.

Switch 6 is used to control the condition for the spindle motor start. Depending on the switch setting the Spindle Motor is started either with the first active going edge of the corresponding DR SEL (Drive Select) signal or when DC power is provided to the drive.

Switch 7: this switch is only used during production for specific tests and motor speed adjustment.

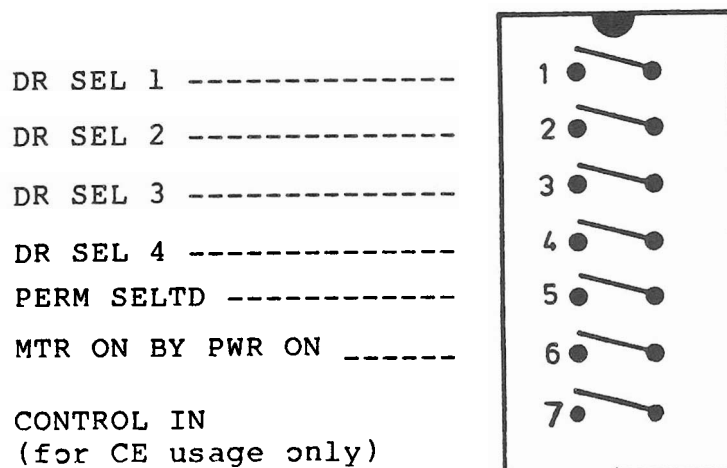


FIGURE 2-1 : OPTION SWITCHES

2.4 FAULT-CODES

The Select-LED is used to flash error-messages in case certain fault conditions should arise. For FAULT code displacement the red colored front panel LED will be lighted. The information is presented in a sequence by switching the select LED off. This means that the dark Phases of the LED are counted to get the error code according to the following table.

e.g. Code 3

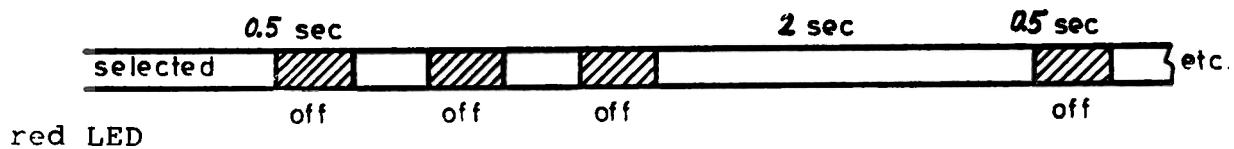


FIGURE 2-2 : ERROR INDICATION

ERROR-CODES:	1	DC ERROR
	2	Motor Speed outside - 10% and Motor stop
	3	STEP received while WRITE GATE is active
	4	Motor Speed outside +_ 1%
	5	REZERO fails after POWER ON
	6	Motor does not rotate inspite of MOTOR ON active
	7	WRITE FAULT

Note: In case the unit was not selected by the Controller when an error occurs (Select LED off) the LED will first be switched on and then the above explained sequence takes place.

3. DRIVE INTERFACE

3.1 INTERFACE SIGNALS

The drive interface consists of three kinds of interface signals: control input signals, status output signals and data transfer signals.

Low active signals are identified with a "/" appended to the signal name.

PIN	SIGNAL
2	RED WRT CUR/
4	HD SEL 2/
6	WRT GATE/
8	SEEK COMPL/
10	TRACK 0/
12	WRT FLT/
14	HD SEL 0/
16	OP CBL DET
18	HD SEL 1/
20	INDEX/
22	READY/
24	STEP/
26	DR SEL 1/
28	DR SEL 2/
30	DR SEL 3/
32	DR SEL 4/
34	DIR IN/

All odd numbered PINs are GROUND.

TABLE 3-1: J1/P1 INTERFACE "A" - CABLE CONNECTOR

Data transfer signals are differential and transmit MFM raw data between the drive and the controller via the interface "B"-cable.

PIN	SIGNAL
1	DR SELTD/
2	GND
3	RESERVED
4	GND
5	SPARE
6	GND
7	OP CBL DET
8	GND
9	SPARE
10	GND
11	GND
12	GND
13	MFM WRT DATA
14	MFM WRT DATA/
15	GND
16	GND
17	MFM RD DATA
18	MFM RD DATA/
19	GND
20	GND

TABLE 3-2: J2/P2 INTERFACE "B" - CABLE CONNECTOR

3.2 ELECTRICAL REQUIREMENTS

3.2.1 SINGLE ENDED SIGNALS

All control input signals and status output signals are single ended and low active (except OP CBL DET). They must meet the following electrical specifications:

Active:	0.0 to 0.4 V DC	I = 40 mA max.
Inactive:	2.5 to 5.25 V DC	I = 0 mA (open)

Figure 3-1 shows the recommended drivers, receivers and termination for the single ended signals. Status output signals must be terminated in the controller. Control input signals must be terminated in the last drive connected to the interface "A"-cable. In a daisy chain configuration, the termination resistor pack at location 2F on the Read-Write-Control PCB must be removed from all but the last drive connected to the interface "A"-cable.

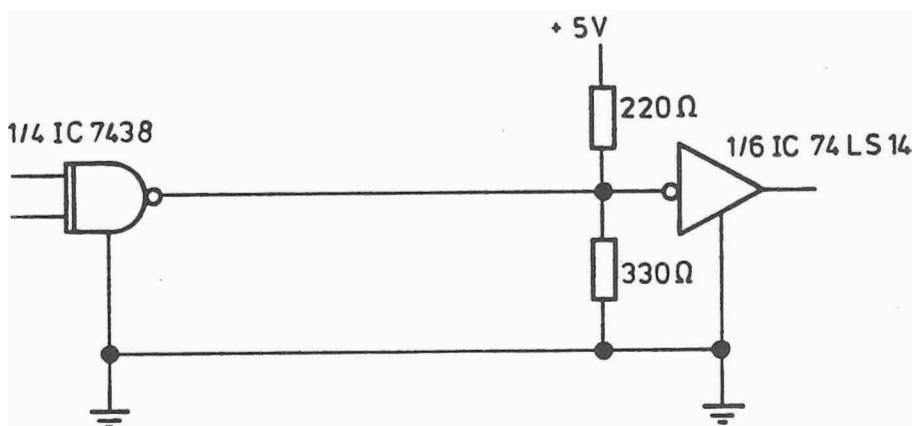


FIGURE 3-1: CONTROL/STATUS LINE CONFIGURATION

3.2.2 DIFFERENTIAL SIGNALS

The data lines between drive and controller are differential. The logic state for the two pairs of lines MFM WRT DATA and MFM RD data is defined as follows:

The signal is in an active state if the high active line (without "/" appended) is more positive than the low active line (with the "/" appended); and the signal is in an inactive state if the low active line is more positive than the high active line.

Figure 3-2 shows the recommended drivers, receivers and termination for the differential signals. Termination must be provided on the receiver in the controller; MFM WRT DATA is terminated in each drive.

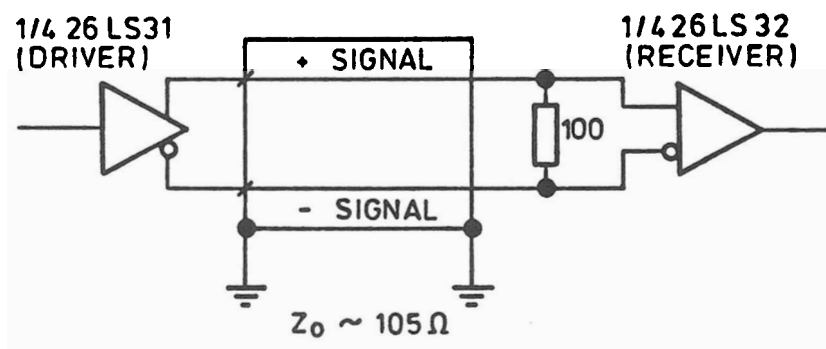


FIGURE 3-2 : DATA LINE CONFIGURATION

3.2.3 POWER SEQUENCING

Power Up and Power Down may be done with any sequence of the supply voltages. Microprocessor control logic prevents any erroneous writing during Power Up or Power Down. The interface signal WRT GATE (Write Gate) must be kept high inactive during any power sequence.

3.3 SIGNAL DEFINITION

3.3.1 CONTROL INPUT SIGNALS

The control input signals transmit commands from the controller to the drive.

3.3.1.1 DR SEL 0-3 (Drive Select 0-3)

These control signals are used for drive selection together with the drive address switches on the Read-Write-Control PCB. An active DR SEL signal selects the drive with the same address. A selected drive enables its input receivers and output drivers and turns on the IN-USE indicator which is mounted in the face plate. When the DR SEL signal is inactive, the drive is deselected and the input receivers and output drivers disabled.

Note: To be valid, only one of the signals DR SEL 0, DR SEL 1, DR SEL 2, and DR SEL 3 may be held active at any one time.

The DR SEL signals may also be used to switch on the spindle motor. The first low going edge of the appropriate DR SEL signal starts the motor. This feature is enabled or disabled with option switch No. 6.

3.3.1.2 DIR IN (Direction In)

This line controls the moving direction of the read/write head assembly driven by the stepper motor, when the STEP line is pulsed. If the DIR IN signal is active and the STEP line is pulsed the head assembly moves towards the disk center, which is defined as "in"; if the DIR IN signal is inactive, the head assembly is moved "out" towards track 0. The DIR IN signal must not change while the signal SEEK COMPL is inactive.

3.3.1.3 STEP

Together with the DIRECTION IN-line this signal causes the read/write head assembly to move in the direction defined by the DIR IN signal. Each STEP pulse causes a head movement across one cylinder, n pulse a movement across n cylinders. Depending on the pulse rate the drive has two operation modes

- a) ramp mode
- b) single step mode

These modes are automatically selected by the drive by sampling the pulse rate.

3.3.1.3.1 Ramp mode

If the time between successive step pulses is between 10 microsec and 200 microsec and the seek has a minimum length then the drive accelerates and decelerates the head tower over a well-defined velocity ramp. If the seek length is less than the minimum limit then the head tower will be stepped at a 1.2 msec rate.

3.3.1.3.2 Single step mode

If the time between successive pulses is between 1.2 msec and 3.1 msec the drive performs the step operation at the given step rate.

3.3.1.4 HD SEL 0 - 2 (Head Select $2^0 - 2^2$)

Through these signals each one of the six read/write heads can be selected in a binary coded form. HD SEL 0 ist the least significant line and HD SEL 2 the most significant. When all HD SEL signals are inactive, head 0 is selected.

3.3.1.5 WRT GATE (Write Gate)

When WRT GATE is active, the data transmitted across the MFM WRT DATA lines is written onto the disk. When WRT GATE is inactive, data is read from the disk and transmitted across the MFM RD DATA lines to the controller.

3.3.1.6 RED WRT CUR (Reduced Write Current)

The signal RED WRT CUR is used to reduce the write current when writing data on inner tracks, where flux densities are higher and head flying heights are lower. This signal is activated by the drive internal microprocessor; pin 2 of J2 is nonfunctional.

3.3.1.7 OP CBL DET (Open Cable Detect)

Connector "A"-Cable, Pin 16 and "B"-Cable, Pin 7 are connected on the drive-side to allow the controller to check if the cables are plugged correctly.

3.3.2 STATUS OUTPUT SIGNALS

The status output signals transmit status information from the drive to the controller.

3.3.2.1 DR SELTD (Drive Selected)

The signal DR SELTED is provided together with the data signals through the star connected the "B"-cable. It returns the selection status of the drive connected to this cable.

3.3.2.2 READY

If both, the READY and the SEEK COMPL line, are active, the drive is ready for writing, reading or executing a seek operation. If the READY line is inactive, writing and stepping are inhibited.

During power up three conditions must be met for READY switching to a true state

- track zero recalibration is completed
- Motor speed tolerance less than 1% of nominal
- WRITE FAULT conditions is false

READY goes away if any of these three conditions is not fulfilled.

3.3.2.3 TRACK 0

This signal is in an active state when the selected drive's read/write head assembly is positioned at the outermost data track of the disk, which is defined as Track 0. The signal is at the inactive state as soon as the head assembly is positioned at any other track.

3.3.2.4 SEEK COMPL (Seek Complete)

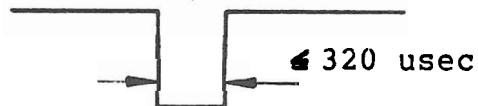
The signal SEEK COMPL is active when the read/write head assembly is positioned on the predetermined track and the heads are settled. Writing is inhibited as long as SEEK COMPL is inactive.

SEEK COMPL is inactive during a seek or rezero operation. It goes inactive typical 70 nanoseconds after the leading edge of the first step pulse. For single step operation it stays inactive until 15 msec after the trailing edge of the last step pulse. In ramp mode operation it stays inactive until 15 msec after the last performed step.

SEEK COMPL is also inactive during the automatic Rezero operation after Power On.

3.3.2.5 INDEX

This pulse occurs on this line once per each spindle revolution. It is derived from a sensor mounted inside the Spindle Motor. The purpose of this signal is to indicate the beginning of the track. INDEX is defined as the leading edge of this pulse.



3.3.2.6 WRT FLT (Write Fault)

WRT FLT is indicated whenever a condition exists, that causes improper writing. The following conditions can cause a write fault condition:

- More than one head selected
- No write current in write mode
- Write current in read mode
- DC voltage out of tolerance

Each of these conditions prevents writing.

To clear a write fault condition, DR SEL and/or WRT GATE must be made inactive.

3.3.3 DATA SIGNALS

The data signals transmit the raw MFM data between the controller and the drive. Data separation, encoding and decoding is provided in the controller.

3.3.3.1 MFM WRT DATA (MFM Write Data)

While WRT GATE is active the controller transmits the MFM encoded data across the pair of differential MFM WRT DATA lines. Each pulse on the interface lines causes one flux reversal on the disk.

The write data must be pre-compensated on all tracks greater than 127. The optimum amount of pre-compensation is +/- 12 ns.

3.3.3.2 MFM RD DATA (MFM Read Data)

While WRT GATE is inactive, the drive transmits the data it reads with the selected head across the pair of differential MFM RD DATA lines. Each flux reversal which is read from the disk generates one active going pulse on the interface lines.

3.4. TIMING REQUIREMENTS

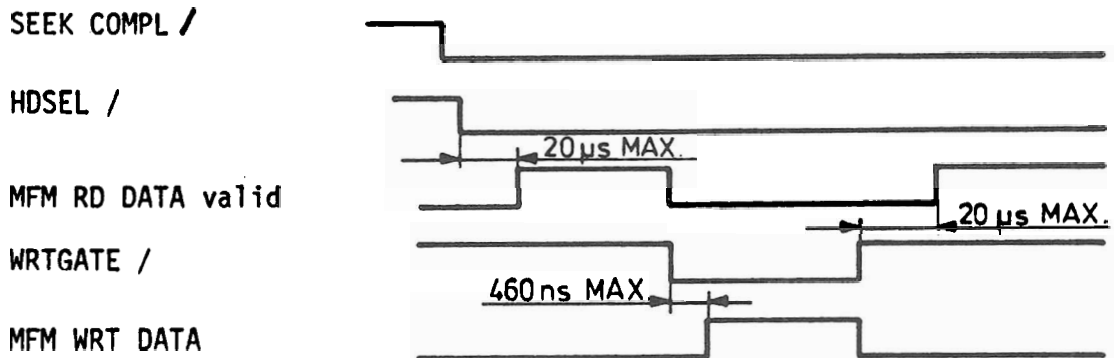


FIGURE 3 - 3 : READ/WRITE TIMING REQUIREMENTS

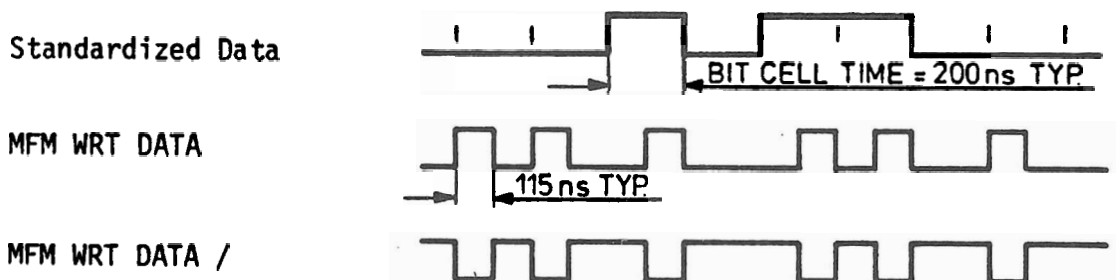


FIGURE 3 - 4 : MFM WRITE DATA TIMING

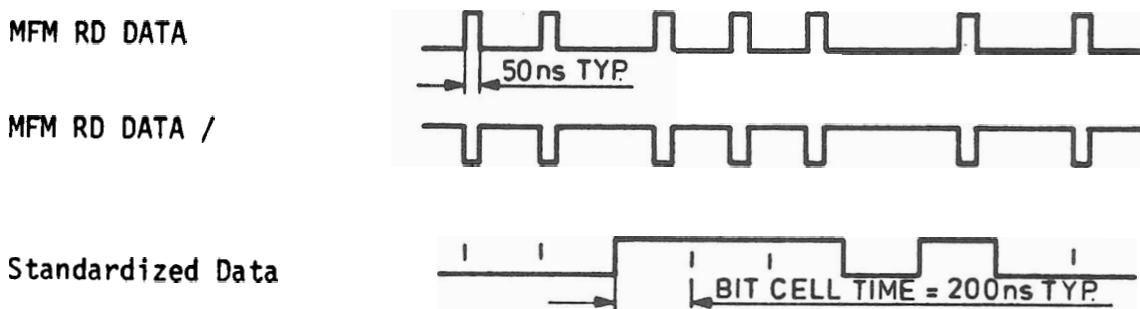
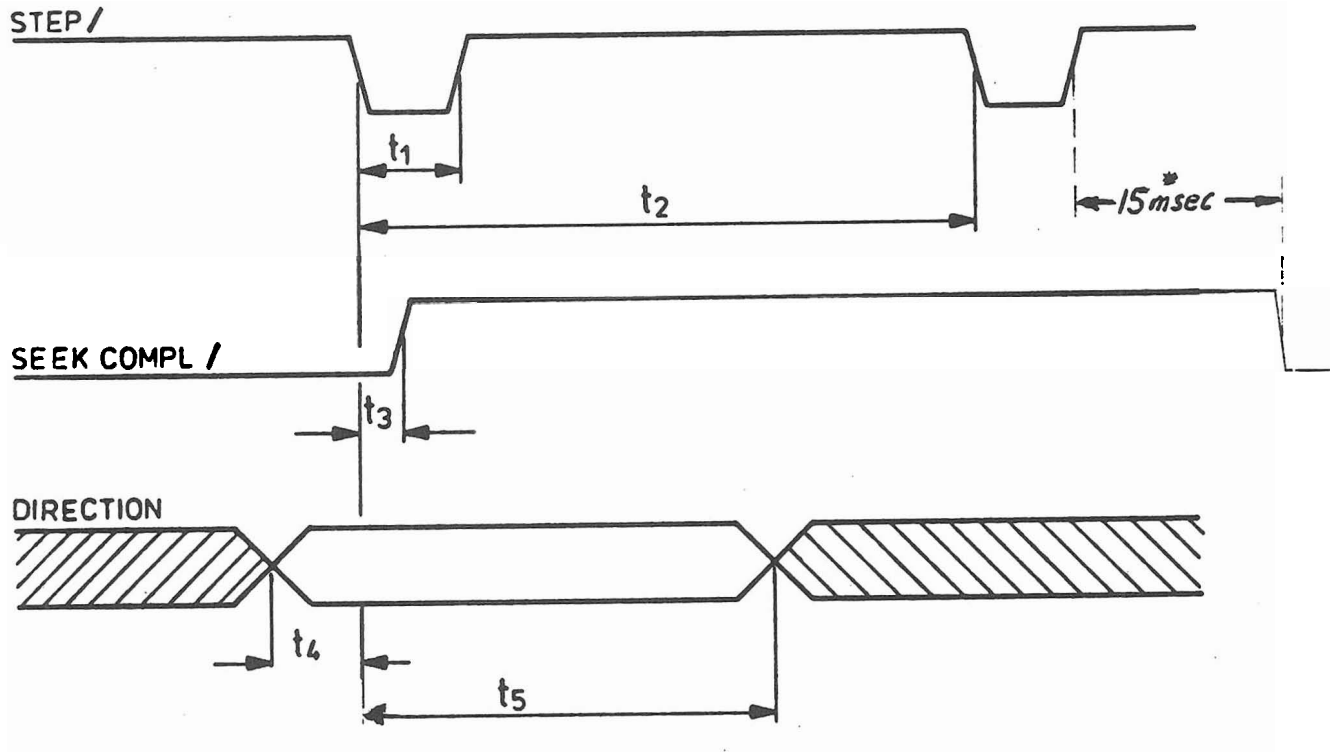


FIGURE 3 - 5 : MFM READ DATA TIMING



Label	Description	Min.	Typ.	Max.	Units
t1	Width of step pulse	0.5	5	-	us
t2	Time between step pulses				
	RAMP-mode	10	-	200	us
	Single-Step-Mode	1200	-	3100	us
t3	Time from first step pulse to Seek Complete inactive	-	70	-	ns
t4	Direction to first step	0	-	-	
t5	First step to Direction	50	-	-	us
t6	Head settling time		15		ms

FIGURE 3-6 : STEP PULSE TIMING

*Note: Head settling time always starts after the last step initiated by the Stepper Motor Control and not by the Controller.

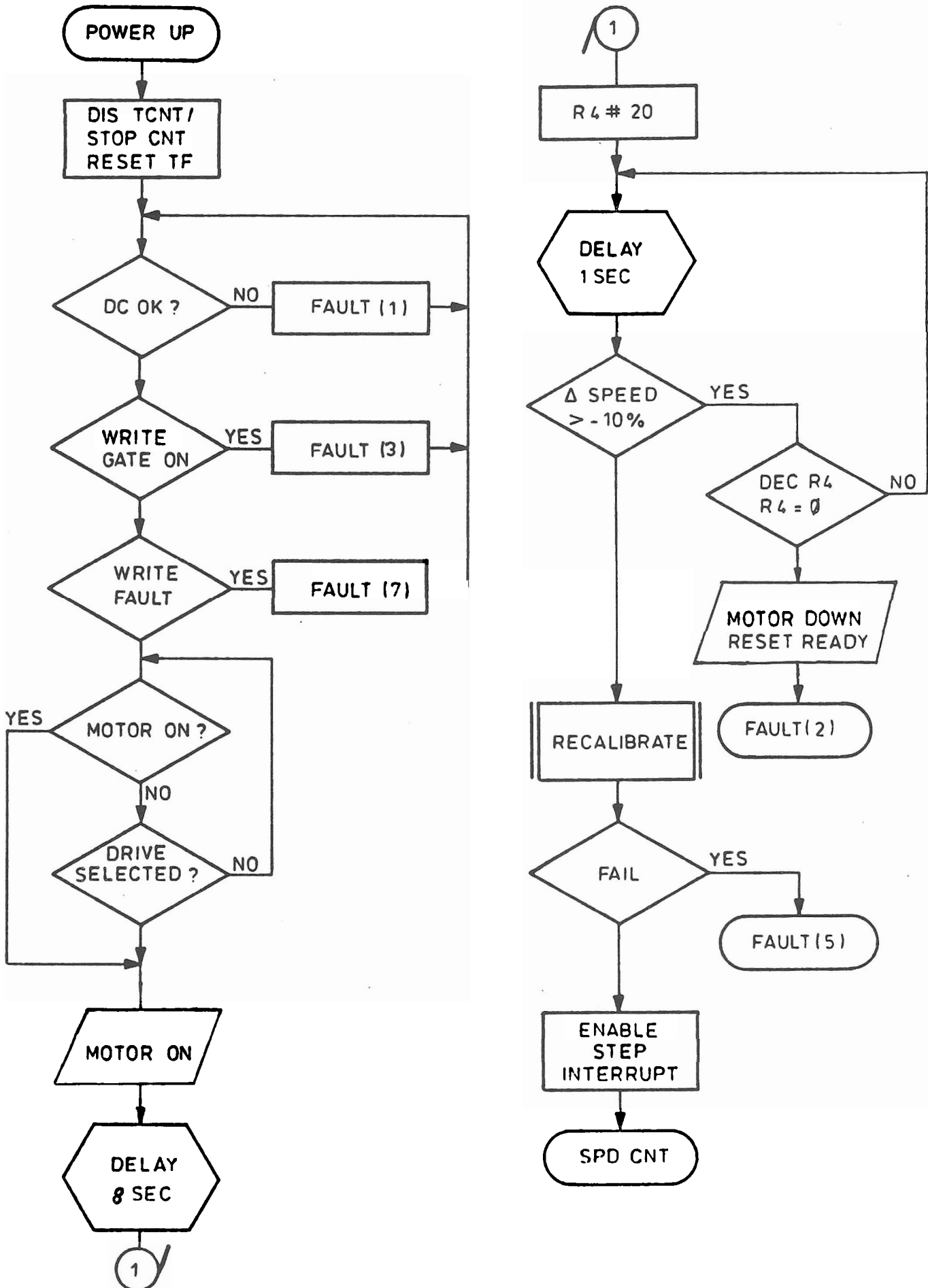


FIGURE 3 - 7 : POWER UP SEQUENCE

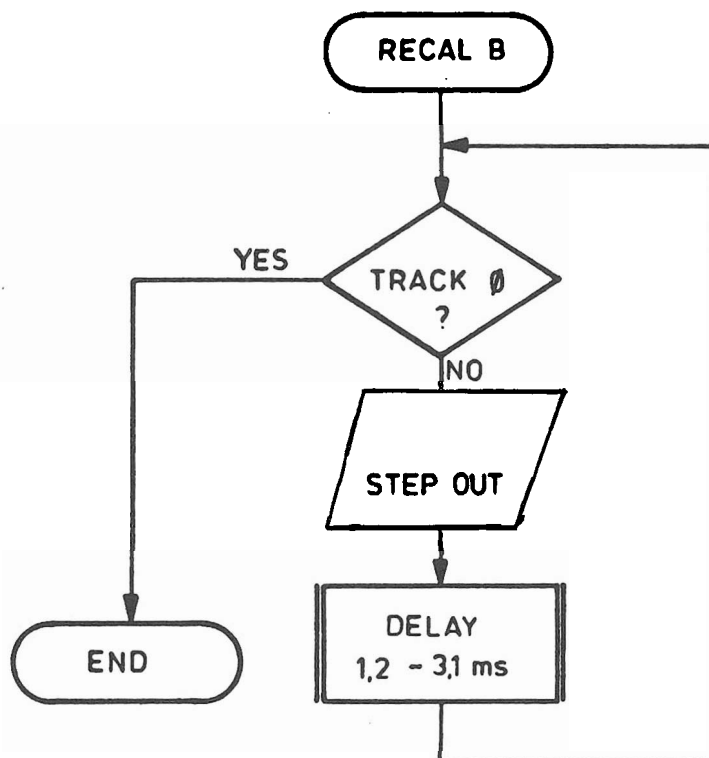
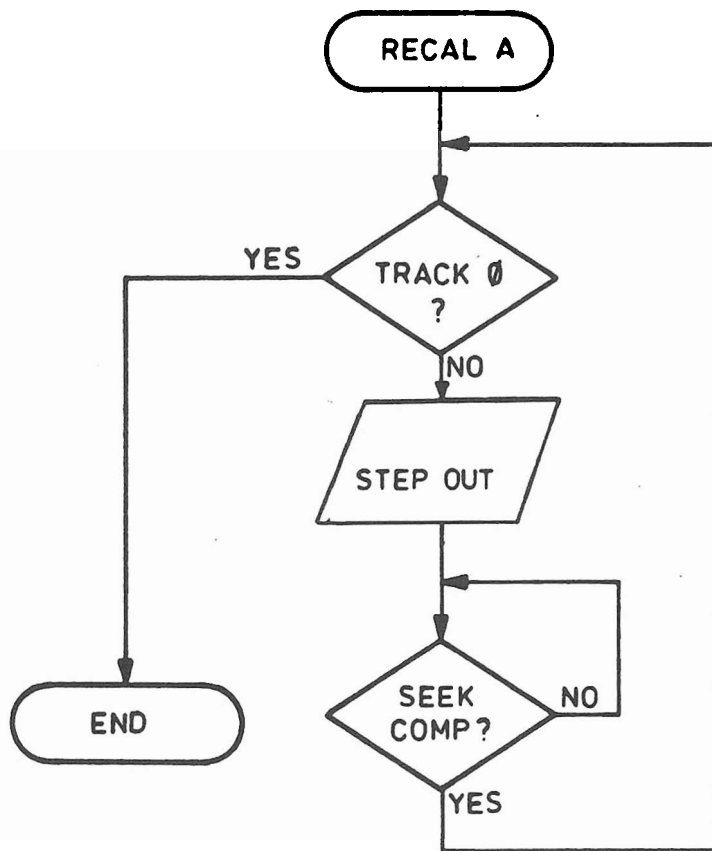


FIGURE 3 - 8 : RECALIBRATION SCHEMES

3.5 PHYSICAL INTERFACE

The physical interface between the BASF 6188 and the controller is done via three or four connectors. One provides the control and status lines through the "A"-cable which may be daisy chained. The second one provides the read/write signals to the star connected "B"-cable. The other connectors are used to supply DC power and for optional frame grounding. All dimensions in the figures are given in millimeters.

3.5.1 INTERFACE CONNECTOR J1, "A"-CABLE

The "A"-cable is connected to the PC-board via a 34 pin card edge connector. Recommended mating connector is AMP P/N 88 373-3, or equivalent.

The "A"-Cable may be daisy-chained if more than one drive is connected to the controller. The cable may be flat ribbon or twisted pair with a maximum total length of 6 m (20 ft).

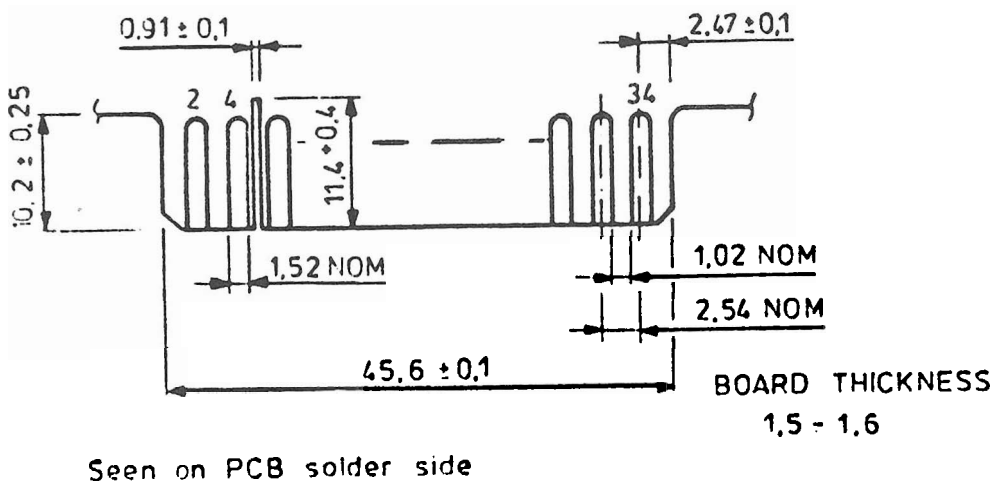
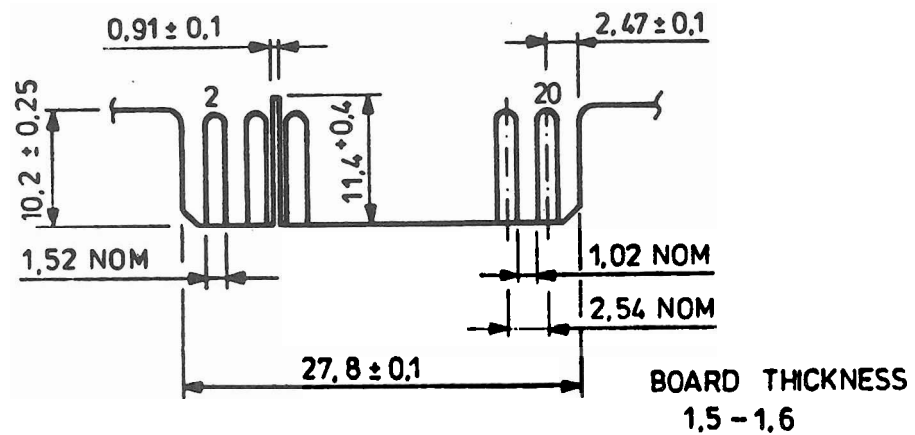


FIGURE 3 - 9 : J1 CONNECTOR DIMENSIONS

3.5.2 INTERFACE CONNECTOR J2, "B"-Cable

The "B"-cable is connected to the PC-board via a 20 pin card edge connector. Recommended mating connector is AMP P/N 88 373-6, or equivalent.

The "B"-Cable must be radially connected if more than one drive is connected to the controller. The cable may be flat ribbon or twisted pair with a maximum total length of 6 m (20 ft). The cable impedance should be around 105 Ohms.

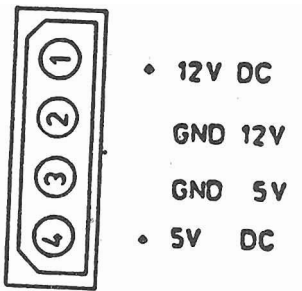


Seen on PCB solder side

FIGURE 3 - 10 : J2 CONNECTOR DIMENSIONS

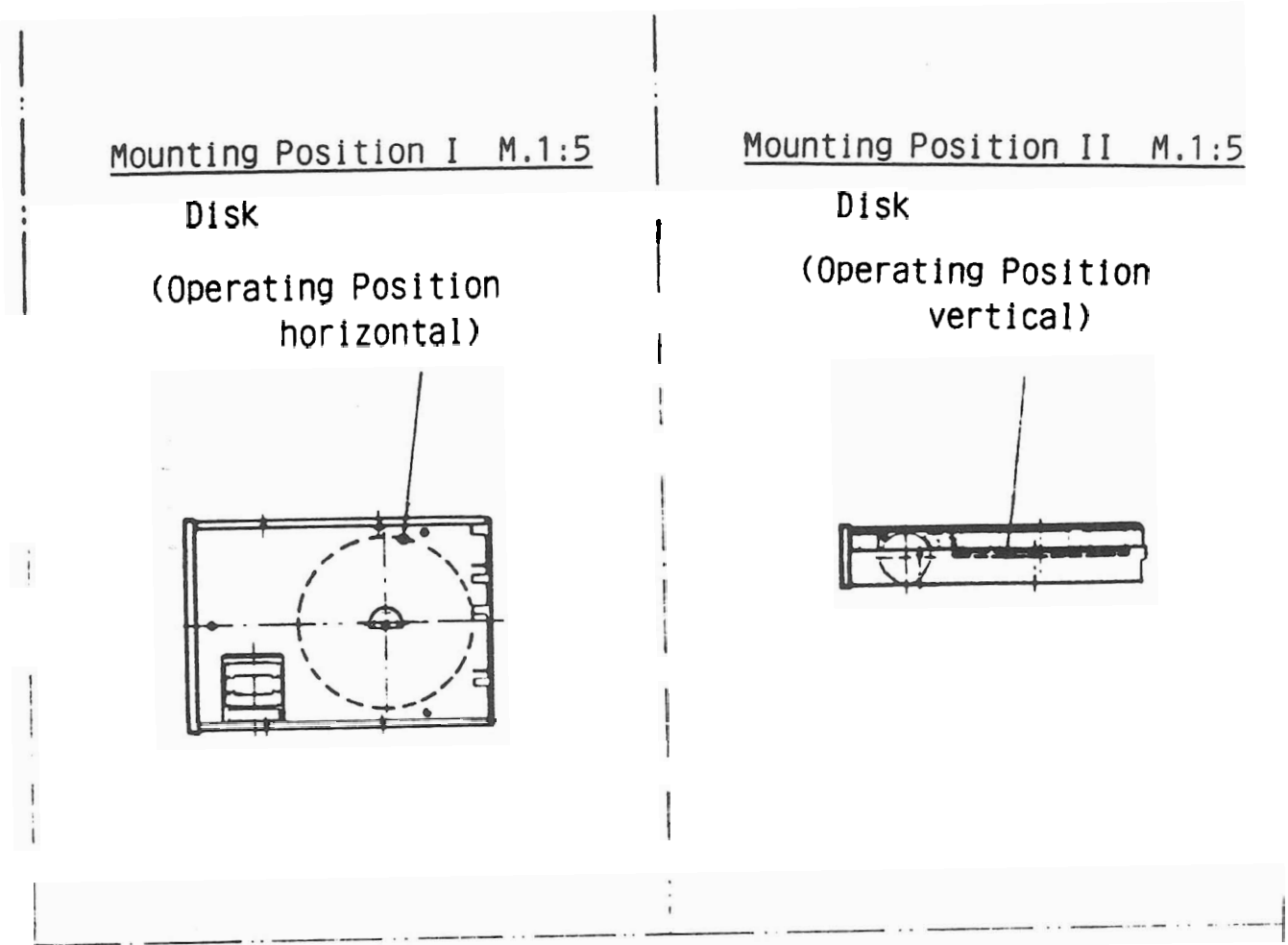
3.5.3 POWER CONNECTOR J3

The DC-power connector is a four pin connector. Recommended mating connector is AMP P/N 1-480424-0 with pins 350078-4, or equivalent.



J3 connector as seen on Drive
PCB solder side

FIGURE 3-11 : J3 CONNECTOR



Recommended Slot

M. 1 : 5

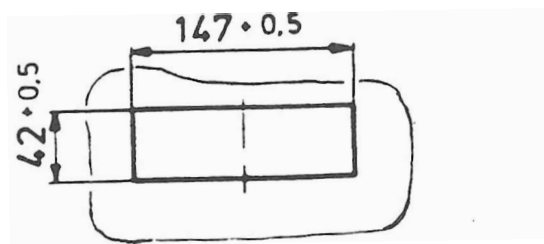


FIGURE 3 - 13 : MOUNTING RECOMMENDATION