

DVD-ROM Drive Specification

Project: Xbox

Author: leodelc

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One Microsoft Way

Redmond, WA 98052-6399

Telephone (425) 882-8080

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Approvals

Approved by:	Date:
_____ Todd Holmdahl, General Manager	
Approved by:	Date:
_____ Leonardo Del Castillo, Lead Electrical Engineer	
Approved by:	Date:
_____ Jeff Reents, Lead Mechanical Engineer	
Approved by:	Date:
_____ Jon Thomason, Lead Software Engineer	

1.Introduction

The DVD drive will be used for loading of content and applications. The DVD must be capable of reading DVD disks, CD Audio disks, and CD-ROM disks. The design shall be based on a single-laser pickup head for lowest cost. The single-laser approach precludes compatibility with CD-Recordable (CD-R) media.

The DVD drive will interface to the system via a pure digital interface. The drive will not include D/A converters and an analog audio interface. Redbook audio playback will be implemented via direct digital readout of the audio data, which will be routed through the memory subsystem to the audio output.

The performance of the DVD drive has been specified to attain the design goals listed below, which have been arranged in order of decreasing importance:

- Provide a means of delivering software to be executed on the Xbox, in the form of DVD-ROM applications, CD-audio, and DVD-movies
- Support real-time playback of HDTV video from any future HD-DVD standard. It is recognized that lacking an existing standard, that no design decision or performance specification shall be made that precludes the possibility of performing this function. It is also understood that there is a possibility that the technical specification for HD-DVD may require functionality not included in Xbox.
- Minimize component cost
- Minimize game start up time
- Minimize system acoustic noise
- Minimize power consumption

2. Functional Requirements

2.1. Physical Media Compatibility

Standard Media: 8cm and 12cm Media

Non-Standard Media: 8cm Rectangular Media of a format to be defined by Microsoft in conjunction with the DVD drive manufacturer. The DVD drive shall be designed for compatibility with this media.

The media format for this form factor may be CD-ROM or single-layer DVD. Dual-layer DVD capability in this form factor is not required.

An example of this media is shown in the sketch below.

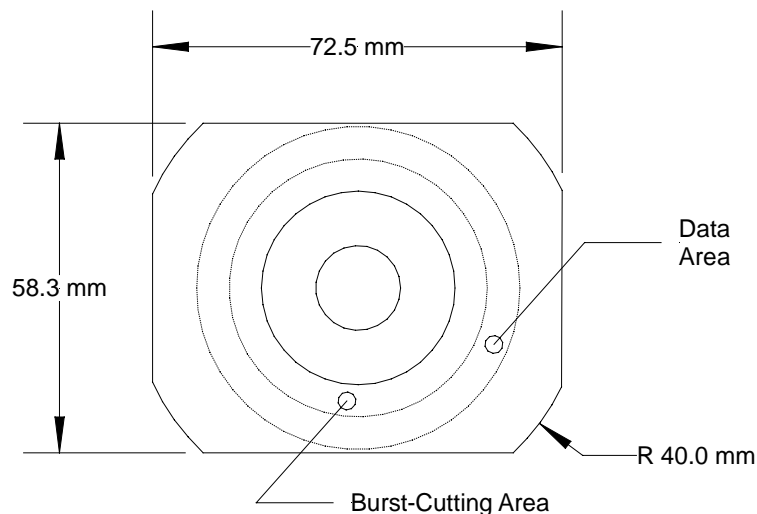


Figure 1. Rectangular Optical Disk Media

2.2. Format Compatibility

DVD-5 / DVD-10 (Single-Layer, 12cm DVD)

DVD-9 / DVD-18 (Dual-Layer, 12cm DVD)

Single-Layer, 8cm DVD

Dual-Layer, 8cm DVD

DVD-R (drive and media is available from limited suppliers)

CD-ROM XA (Yellow Book)

CD-DA (Red Book)

CD-RW (Read only) (TBD- the may be standardization issue wrt CD-RW)

Video CD (White Book, hardware support only, software support is TBD) (There are issues with quality of media)

2.3. Spindle Speed Control

The drive shall operate at Constant Angular Velocity (CAV) in both CD and DVD formats. The maximum spindle velocity shall be selectable under software control, but the actual spindle velocity may be lower due to vibration or error rate minimization.

2.4. Performance Requirements

Parameter	Min	Typical	Max	Unit
Reference Streaming Speed 1x DVD 1x CD-ROM Mode 1 1x CD-ROM Mode 2 1x CD-DA		11.08 1.23 1.40 1.41		Mbps
CAV rotational velocity Single Layer DVD Dual Layer DVD All CD formats	1148 1148 1148		2870 3160 3160	rpm
Relative DVD Streaming Speed (read only, CAV) 12cm Media 8cm Media Rectangular Media	2x 2x 2x		5x 3.3x	
Sustained DVD Data Rate 12cm DVD Media 8cm DVD Media Rectangular DVD Media	22.16 22.16 22.16		55.40 36.56 TBD	Mbps
Relative CD Streaming Speed (read only, CAV) 12cm Media 8cm Media Rectangular Media	6.4x 6.4x 6.4x		16x 9x	
Sustained CD Data Rate 12cm CD-ROM Mode 1 12cm CD-ROM Mode 2 12cm CD-DA 8cm CD-ROM Mode 1 8cm CD-ROM Mode 2 8cm CD-DA Rectangular Media	7.87 8.96 9.02 7.87 8.96 9.02 TBD		19.68 22.40 22.56 11.07 12.60 12.69	Mbps
Startup Time (This parameter is to be minimized) DVD-5 DVD-9		8 8	TBD TBD	sec
Launch Time (This specification is provided for reference) DVD-5 or DVD-9		18		sec
Spin-down Time			8	sec
Tray Open/Close Time			4	sec
Random Seek Time (1/3 stroke, at max angular velocity) CD DVD-5 DVD-9		100 130 130		ms
Full-Stroke Seek Time (1/3 stroke, at max angular velocity) CD DVD-5 DVD-9		300 300 300		ms

Parameter	Min	Typical	Max	Unit
Time to restart from Idle			5	sec

2.4.1. Performance Optimizations

The DVD drive shall be designed to optimize application startup time when DVD-ROM media is loaded. For this reason, certain operations will be modified from a standard DVD-ROM drive. In a standard DVD-ROM drive, if the media is dual layer, then the drive will automatically calibrate for both layer 0 and layer 1. The additional calibration takes time, but ensures that both layers are available for reading. This is important in DVD movie playback, as the drive must perform a layer change while seamlessly displaying the movie.

In the Xbox application, performance would be optimized if the layer 1 calibration is deferred until after the launch file is loaded. When an Xbox title launches, the first file that is loaded (the launch file) contains executable code that contains the application. Data from layer 1 will not be needed immediately, so the OS or application can select a more convenient time to perform the calibration.

Thus, the preferred order of operations the drive must perform following a tray-close event are as follows:

(Note: the optical pickup head is automatically moved to the inside track position for tray open and close operations, thus, the pickup head is assumed to be in the inner track location upon tray close.)

Accelerate spindle to maximum angular velocity;

attempt to identify media, with highest priority being DVD media;

if the media is dual-layer DVD, then calibrate only for layer 0;

the OS will first read the root directory of the DVD-ROM, and typically seek to the launch file, located physically near the outer edge of the media, where linear velocity is highest;

the OS will load the file, which is no larger than 64MB;

the OS will command the DVD drive to perform layer 1 calibration.

2.4.2. Performance benchmarks

A software tool shall be supplied by Microsoft to measure the specified access time parameters. The tool shall be run using a standard test disk meeting the quality standards for Xbox DVD media as defined in a separate document. All transfers referred to in the document shall be made using the fastest DMA transfer mode, and without collisions with data packets from a second device on the same bus.

For the purposes of this specification, the following definitions apply:

Access Time – The time that elapses between an ATAPI command to read data from the disk and when the first data is transferred via the ATA interface. For practical purposes, this time includes the ATAPI command transit time, seek time, rotational latency, read/ECC time, and ATA data transit time.

Average Access Time – This represents the average time required to access data from the disk. This performance metric shall be measured by the following profile- the seek shall originate on any track on the disk to a track 1/3 of a stroke away; the seeks shall include an equal number of inner to outer and outer to inner seeks; the tool shall accumulate a minimum of 200 seeks and compute the average by dividing the total amount of time required to perform the test by the number of seeks performed.

Full Stroke Access Time – The access time for a seek that originates in the vicinity of the innermost track, to the outermost track, or from the outermost track to the innermost track. This performance metric shall be measured by making subsequent inner to outer and outer to inner accesses, accumulating a minimum of 200 seeks, and dividing the total time elapsed by the number of seeks performed.

Startup Time – The time elapsed between the tray close and the first drive being ready to complete the first data transfer request. This metric shall be measured using the standard test disk. The time shall be measured from the point at which the tray reaches the “closed” position, and shall include the spindle startup time; the media detection and laser calibration time; and the read of the DVD-ROM root directly.

Launch Time – The time elapsed between the tray close and the first 64MB launch file being transferred from the disk. This specification is provided for reference only, as an indication of the time required to launch a typical application from DVD. The actual time required to launch an application will vary depending on the physical location of the launch file, the exact size of the file, and the quality of the DVD media.

This metric shall be measured using the standard test disk, containing a 64MB file located near the vicinity of the outermost track on the disk. The time shall be measured from the point at which the tray reaches the “closed” position, and shall include the Startup Time (as defined above); the time required to seek to the launch file; and the transfer of the complete 64MB launch file.

Sustained Data Rate – The rate at which data may be read continuously from the disk and transferred via the ATA interface, averaged over a large data file located on contiguous physical tracks. The time shall be measured between the first ATAPI command to read data following a seek command, to the final data being transferred. The rate shall be computed by dividing the size of the data file and dividing by the time elapsed.

3. Electrical Requirements

The electrical interface shall consist of two ports, including an ANSI ATAPI compatible interface port and an auxiliary power and loader control interface.

3.1. ATA Electrical Interface

The ATAPI interface shall operate over an ATA-33 physical interface. The ATA interface connector shall be a 40-pin header with 2.54mm center-to-center pin spacing, conforming to ANSI SFF 8059.

The ATA interface utilizes 3.3V signaling. The interface must support DMA Multiword modes 0-3, and DMA-33. The PIO modes are not required. The pin-out of the ATA interface is shown in the table below:

Pin	Function	Pin	Function
1	RESET#	2	GND
3	DD7	4	DD8
5	DD6	6	DD9
7	DD5	8	DD10
9	DD4	10	DD11
11	DD3	12	DD12
13	DD2	14	DD13
15	DD1	16	DD14
17	DD0	18	DD15
19	GND	20	KEY (no pin on header)
21	DMARQ	22	GND
23	DIOW#	24	GND
25	DIOR#	26	GND
27	IORDY	28	NOT USED (CABLE SELECT)
29	DACK1#	30	GND
31	INTRQ	32	IOCS16#
33	DA1	34	PDIAG#
35	DA0	36	DA2
37	CS1FX#	38	CS3FX#
39	DASP#	40	GND

Figure 2. ATA Interface Connector Pin Out

The drive shall support the standard ATAPI commands as described in the API Requirements section of this document.

3.2. Region Coding

The drive shall be designed to support a means of storing a region code as required for DVD movie players. The region code consists of three bits, coded to correspond to region codes 1-7. The region code shall be stored in a one-time programmable memory device. Programming of the region code shall be initiated via the ATAPI interface to enable programming of the region code during system integration.

The components required to store the region code shall be left unpopulated on the drive unless a it is determined to be required to meet license requirements.

3.3. Content Scrambling System Support

The DVD drive shall implement the ATAPI command set related to CSS decryption as required for a standard PC DVD-ROM drive.

3.4. Microcontroller Technology

A microcontroller utilizing flash memory technology may be used in order to expedite the implementation of the DVD drive design into production. Flash technology may be used, with the following restrictions:

The flash memory of the microcontroller must be protected by a security bit such that the code contained in the microcontroller may not be read out from a unit in the field.

The flash memory may be used to store the region code so long as the code is programmable in the field in a one-time-programmable fashion.

Accidental erasure of the flash memory shall be precluded by design- no combination of errant ATAPI commands may alter the contents of the flash after the region code is programmed.

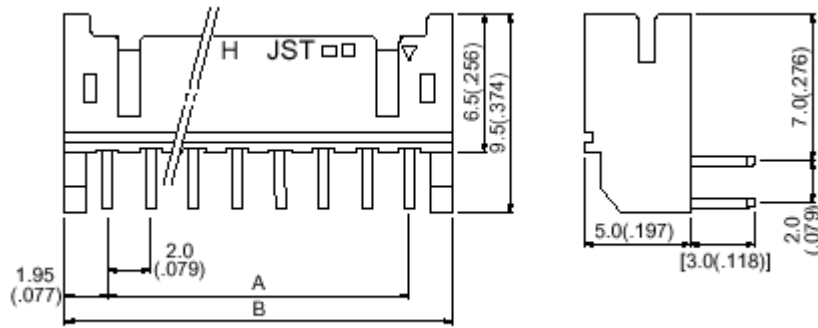
3.5. Power and Control Interface

12VDC power and the loader control/status interface shall be implemented on a secondary multi-pin connector. The interface shall include the following signals (Note signal directions are with respect to the drive):

Pin	Signal Name	Direction	Comment
1	12VDC	POWER	12VDC for motor control
2	5VDC	POWER	5VDC for digital logic
3	GND	POWER	Signal and DC current return
4	EJECT	IN	Logic level control, when asserted LOW, tray is ejected. When de-asserted (OPEN or HIGH) tray is closed.
5	TRAYSTATE0	OUT	The combined states of these signals indicate the current state of the tray and media as defined in the state diagram below.
6	TRAYSTATE1	OUT	
7	TRAYSTATE2	OUT	
8	ACTIVITY	OUT	Asserted LOW when disc activity (seek or data transfer) occurs.
9	12VDC	POWER	12VDC for motor control
10	5VDC	POWER	5VDC for digital logic
11	GND	POWER	Signal and DC current return
12	GND	POWER	Signal and DC current return

Figure 3. DVD Power and Control Interface Connector Pin Out

The connector type shall be JST part number S12B-PHDSS or equivalent, as shown in the drawing below. Pin one is designated with a triangular marking on the connector shell. Odd numbered pins are on the top side of the connector, while even numbered pins are on the bottom side.



A= 10.0 mm, B=13.9mm

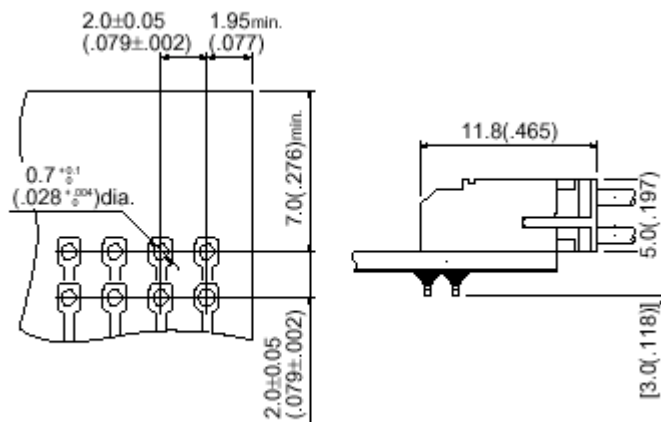


Figure 4. DVD Power and Control Interface Connector

The Power and Control interface includes three state bits that are driven by the DVD drive to indicate the current state of the DVD mechanism. The state diagram below defines the state transitions and the inputs or conditions that trigger changes between states.

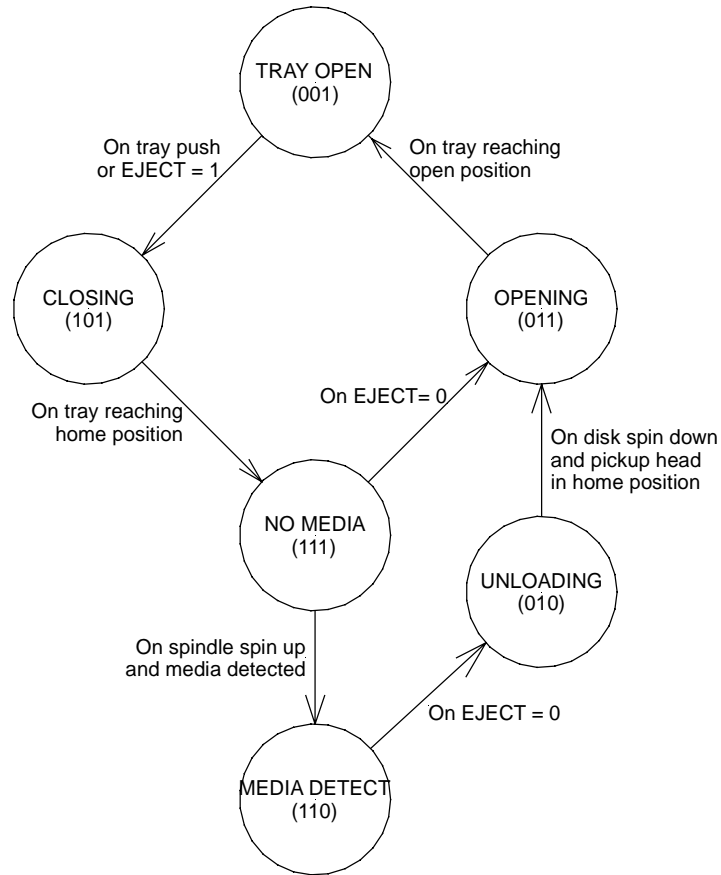


Figure 5. DVD Mechanism State Diagram

State Definitions:

TRAY OPEN – This state indicates the disk tray is fully open.

CLOSING – This state indicates the tray is the process of closing.

NO MEDIA – This state indicates the disk tray has closed, and the drive is attempting to detect if media is present. If no media is inserted in the drive, the drive remains in this state until ejected by EJECT=0.

MEDIA DETECT – This state indicates that the tray has closed and the valid media has been detect in the drive.

UNLOADING – This is a temporary state entered upon EJECT=0 that persists until the tray begins to open.

OPENING – This state indicates the tray is being opened.

3.6. DC Electrical Characteristics

Parameter	Min	Typical	Max	Unit
Logic Supply Voltage (V_{CC5})	4.75	5.00	5.25	V
Logic Supply Current Seek Read Idle (disc not spinning)		800 250	900	mA
Motor Supply Voltage	10.8	12.0	13.2	V
Motor Supply Current Seek Read Idle (disc not spinning)		600 100	1300	mA
Input Logic Level (ATA bus, control, and state outputs) Voltage Input, Low (V_{IL}) Voltage Input, High (V_{IH})	0.0 2.0		0.8 V_{CC5}	V
Output Logic Level (ATA bus, control, and state outputs) Voltage Output, Low (V_{OL}) @ 300 μ A Voltage Output, High (V_{OH}) @ 300 μ A	0.0 2.7		0.6 V_{CC5}	V

4. Software Requirements

4.1. ATAPI Command Set

The DVD-ROM drive shall support control and data transactions using the ATAPI interface. The drive shall support ATAPI commands to support the following Windows NT API calls:

- SCSIOP_READ (0x28)
- SCSIOP_READ_CAPACITY (0x25)
- SCSIOP_READ_CD (0xBE)
- SCSIOP_READ_TOC (0x43)
- SCSIOP_REQUEST_SENSE (0x03)
- SCSIOP_TEST_UNIT_READY (0x00)
- SCSIOP_READ_DVD_STRUCTURE (0xAD)
- SCSIOP_REPORT_KEY (0xA4)
- SCSIOP_SEND_KEY (0xA3)
- SCSIOP_START_STOP_UNIT (0x1B)

4.2. Start-up Sequence and Calibration

The start-up sequence and calibration behavior of the DVD drive is specified in this document differs from that of a standard DVD-ROM drive. As described in the section entitled Performance Optimizations, the DVD-ROM drive shall defer the pickup head calibration for layer 1 until such a time as the host requests a data read from an logical block located on layer 1.

Thus, the drive shall not automatically calibrate to layer 1 until the host requests data from layer 1. It should be noted by the software developer that the delay incurred in accessing this first logical block from layer 1 shall be increased by the amount of time that is required to calibrate the pickup head.

In general practice, the XOS will force a read from layer 1 sometime after the launch file is loaded and begins to execute, such that the layer 1 calibration takes place while the launch file is being processed.

5. Mechanical Requirements

The DVD drive shall have the following mechanical features:

The loading system shall be a standard front-loading tray designed for horizontal operation, within a maximum tilt angle 10° from the horizontal plane.

The drive shall include a tray eject actuator, accessible via a pinhole in the front panel, to release the tray mechanism in the case of a drive failure.

The tray shall automatic close when pushed manually.

Mounting shall be via four screws (two on each side), with the option to investigate a screwless system.

The tray shall be a custom color specified by Microsoft, with an option to have industrial design input of the tray.

The tray shall be designed to accept a cosmetic snap-in door bezel. The door bezel shall be designed and manufactured by Microsoft to match the attachment features defined by the drive manufacturer.

The spindle motor shall be of the brushless type. Future design revisions of the DVD drive may utilize a brush motor for this function only if the manufacturer can demonstrate that the motor meets the specifications for performance and reliability.

Plastic parts in drive assembly to meet UL 6500 for fire enclosure and Environmental Specification for Blue Angel

The drawing below shows the rough mechanical envelope for the DVD drive. Note that the detail of the tray attachment to the cosmetic bezel is at this point TBD. Guideline dimensions for media clearance, and tray protrusion have been provided.

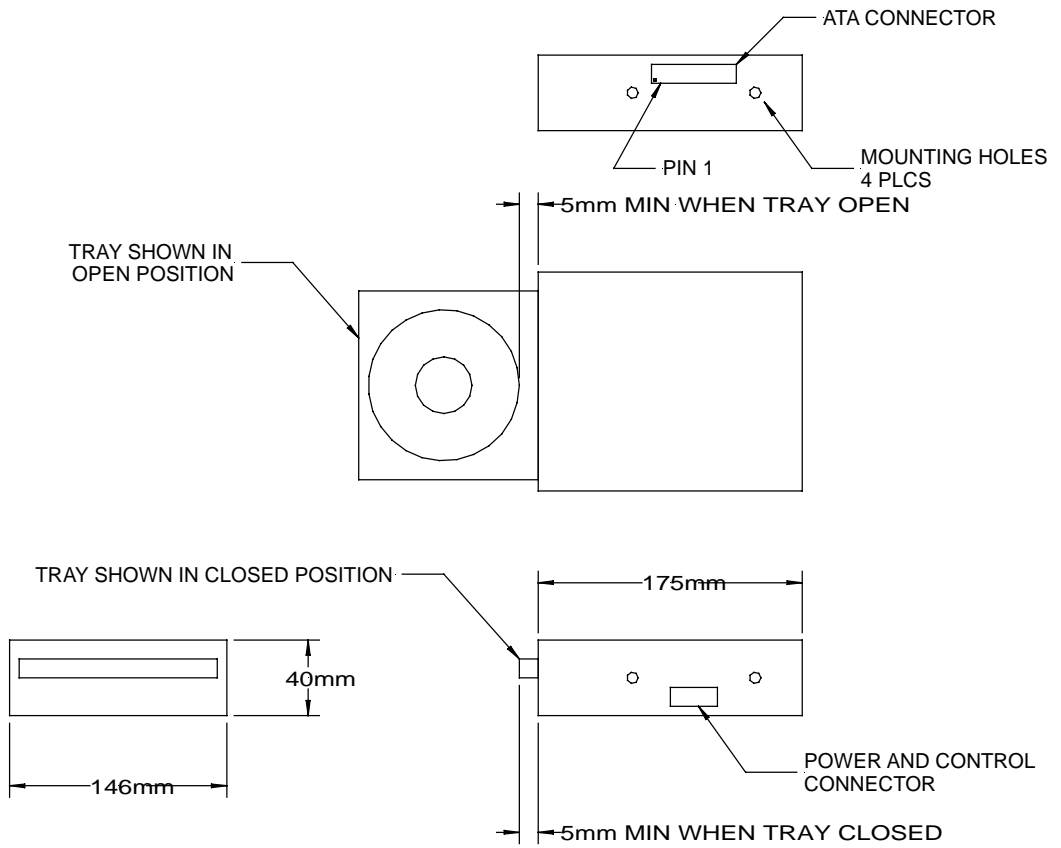


Figure 6. DVD Drive Mechanical Envelope

6.Environmental Requirements

Parameter	Min	Typical	Max	Unit
Ambient Air Temperature In proximity of the pickup head Elsewhere in the assembly	0		55 60	C
Non-Operational Drop Shock, 4ms pulse duration			300	G
Acoustic Sound Power L_w (A) @ 1m Measured while tray opens/closes Measured while Disk is spinning at max velocity Measured in anechoic chamber with background noise level at least 10dBA below the expected measured level			33 30	dB