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Acorn

Connection of Multiple Hard Discs to 32 Bit Acorn Machines

This document describes the procedures required to connect second and (where possible) subsequent hard discs to Acorn systems. The properties and restrictions of the available drive buses are discussed, and details of drive compatibility and some appropriate link settings are provided.

Applicable Hardware : All 32-bit Acorn systems

Related Application Notes: 273: CD ROM Drives and their Handling under RISC OS Explained

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Introduction

With the exceptions of the Archimedes 300 series, the R225, the A3000 and the A3010, all 32-bit Acorn systems have been supplied either with a hard drive as standard or with a built-in interface to allow a hard drive to be added as a user upgrade. As users write or acquire more software and their first hard drive begins to reach capacity, many consider the option of adding further drives to increase their system's available random-access storage. This document details how this may be done, and what the limitations imposed by each of the possible upgrade routes are.

Since the launch of the Archimedes range in 1987, Acorn have produced systems containing one of three types of hard disc interface. These are:

ST506:
This interface was standard on the Archimedes 440, 400/1 series and R140. ST506 allows a maximum of two devices to be linked together on the same ST506 interface. ST506 has been almost entirely superseded by other drive standards, and as such ST506 drives are now extremely difficult to obtain.

SCSI:
This interface was standard on the Archimedes 540 and R260. SCSI interfaces can still be added as an Acorn standard ugrade to systems capable of taking full-size (A5000-style) expansion cards; all you need to do is fit an appropriate SCSI interface, such as Acorn's own AKA32. Third parties also producs SCSI interfaces for systems which accept A3000-style expansion cards.
Up to seven drives may be daisychained on a SCSI bus, although restrictions in some versions of the SCSIFS module may only allow up to four drives or partitions to display their icons on a RISC OS icon bar. SCSI has been a widely recognised drive standard on high-performance systems for many years, and is enhanced SCSI variants may continue to be so for many more; SCSI drives are widely available, and SCSI tends to be used to interface the highest storage capacity drives. SCSI drives of up to 9 Gb capacity are currently available.

IDE:
This interface is standard on the A3020, A4000, A5000, A7000 and Risc PC. The interface is present on the floppy-only version of the A3020, even though it is not used. Up to two drives can be linked together on the same IDE interface. IDE is rapidly becoming the drive interface standard for low and medium performance-range desktop systems, and IDE drives of up to 2 Gb capacity are currently available.

Drive capacity and mapping

Production releases of the FileCore module prior to 2.91 (as shipped with RISC OS 3.6) are only capable of addressing filesystems of size <=512 Mb. This means that, without the use of partitioning software, only drives of formatted size <=512 Mb may be added. Larger drives than this will require partitioning using third party software. Formatting of ST506 and IDE drives can be handled by !HForm, supplied with all machines; SCSI drives cn be handled by either SCSIDM (for the Acorn card; third parties will have different software) or the new (RISC OS 3.6) version of !HForm. This new !HForm will also cater for >512Mb contiguous partitions on large drives.

For earlier iterations of FileCore, a soft-loadable version for use with RISC OS 3.5 is in testing.

CD ROM bus support capability

In addition to hard drives, it is often possible to connect other peripherals to these drive buses; CD ROMs are the most common peripheral to connect in this manner.

ST506:
No CD ROM drives have been produced with an ST506 interface.

SCSI:
It is possible to add CD ROM drives onto an existing SCSI chain; the same procedure used to attach hard discs is used for CD ROM drives, and the same interfacing standards must be complied with. When adding a CD ROM drive, make sure that no hard drives have higher-numbered SCSI IDs than it. The CD ROM drives currently supported by Acorn-originated drivers are:

Sony CDU6111, CDU6211, CDU541, CDU561
Philips CM131, CM231
Toshiba XM2200A, 3301
Hitachi CDR1650S, CDR1750S
Chinon CDS-431

Drivers for other models of CD ROM drive are available from assorted third parties, such as Cumana and Alsystems; see Appendix A.

IDE:
A CD ROM drive may be added to an IDE bus as the slave device; however, not all drives are guaranteed to work with the combination of bus controller and mastering hard drive shipped as standard. Currently, IDE CD ROM drives have only been tested with the Risc PC (which uses a 37C665 controller) and the Conner CFS210A, CFS420A, CFS425A and CFS850A hard drives which are fitted to the different versions thereof; the Panasonic CR562B is an appropriate drive to install on a RISC OS 3.5 system, and the Sony CD50E ATAPI unit is known to work on a RISC OS 3.6 machine (the latter contains the CDFSSoftATAPI driver in ROM)

Adding a Second ST506 Drive

In all cases, the user will be required to change the status of links on the drives to enable them to operate together; details of link configuration should be supplied with the additional drive.

Archimedes 400/1
Approximately halfway up the left hand side of the PCB (facing from front to rear of the machine; note that the backplane will need to be removed before a clear view of the sockets can be obtained) are three sockets labelled SK8, SK10 and SK11. SK10 is a 20 way socket to which the first DATA cable connects; the other end of this cable is connected to the first hard drive. SK8 is a second 20 way socket which can be used to run a separate DATA cable to a second hard drive. SK11 is a 34 way socket to which the CONTROL cable connects; the 34 way CONTROL cable should be daisychained to run to both the internal and external Hard Discs. The interface is normally configured to support up to eight heads per drive; by changing both LK12 and LK13 from their default positions to their alternative positions, up to 16 heads can be supported. This action removes the reduced write current capability provided by the interface, but this tends not to be used externally by larger capacity Hard Disc units.

Archimedes 440 / R140
Much of the information required for the pre June 1989 440 systems is identical to the 400/1 system upgrade. The differences lie in the cable sockets and the link numbers. The two sockets used for connecting the first hard drive are SK10 for the CONTROL cable and SK9 for the DATA cable. The DATA cable for the second drive attaches to socket SK8.

The two links which require altering to enable dual drive support are LK3 and LK4; LK3 should be set

EAST and LK4 should be set WEST. The other details regarding the daisychaining of the CONTROL cable are the same as above.

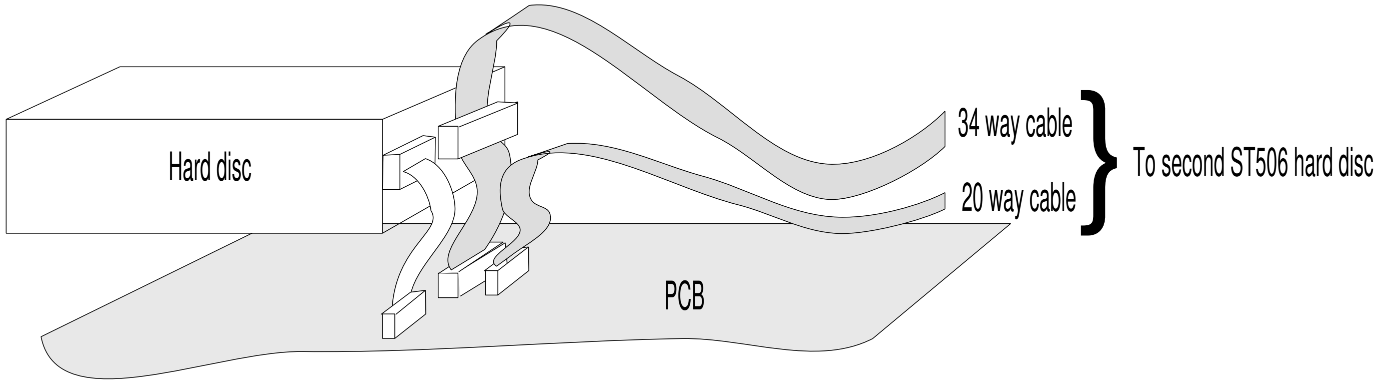

Figure 1: ST506 Drive Connections

Drive compatibility

The interface type supplied by Acorn is ST506 MFM (Modified Frequency Modulation). Drives designated as RLL will work, although it will not be possible to use the full storage capacity of the drive; as a rule of thumb, it is generally possible to map up to 66% of the design capacity of an RLL unit.

Drives to be attached should have an access time of 28ms, no more that 1024 cylinders and no more than 16 heads.

Termination

A very important point to note, and one which is often forgotten, is that only the second drive (at the end of the data cable) in a two-drive system should be terminated. On examination of the PCB on the first drive, it is possible to find one or more terminating resistor packs; these are usually sited close to the data cable connector, and may resemble either a small resin-encased SIPP chip or a DIL package. Usually the terminator packs are brightly coloured to aid identification, and invariably they are socketed rather than soldered. Once the fitting positions (and orientations, in the case of DIL packages) of the terminators on the first drive have been noted, they should be removed.

A Note on Drive Availability

The popularity of the ST506 interface standard was beginning to wane by 1990; when IDE appeared, this decline was accelerated. Today, ST506 drives are very difficult to obtain; unless a user already has an ST506 drive to hand, it is more advisable to add a second drive interface conforming to a more current standard and then fit an appropriate drive to it rather than attempt to procure an ST506 drive.

Adding Second and Successive SCSI Drives

Probably the most flexible, and certainly the most expandable, drive interface bus for Acorn systems is SCSI. A SCSI bus supports a maximum of 8 devices, numbered 0 through 7; however, drives and other peripherals can only be used as devices 0 through 6, as device 7 is reserved for the "host adaptor," otherwise known as the SCSI interface card. A properly-designed SCSI device chain should appear to be a continuous "run" of cable, with a terminator at each end. Cable spurs (between the main backbone of cable and the connector on the back of the drive) should not exceed 100mm in length. The backbone cable should be 50 way twisted pair or IDC ribbon, with between 80 and 90 ohm impedance.

When adding drives to an Acorn SCSI interface, you should make sure:

- that all drives are compatible with the ANSI X3.131 - 1986 SCSI Standard, and with the guidelines in document CCS X3T9.2/85-52 Revision 4B

• that the drives are numbered sequentially, with numbering starting from 0

• that no CD ROM drives have SCSI ID numbers lower than numbers assigned to hard discs

Termination

The SCSI interface is open collector, and hence termination is required at both ends of the bus to pull all the signal and control lines up to the appropriate level (typically 2-3V). A terminator pack should be fitted to the device closest to each end of the SCSI cable; termination should be disabled on devices between these. On more modern SCSI drives, termination can often be disabled by changing the status of a jumper rather than by physically removing socketed termination packs; check the device documentation, or consult the device manufacturer, for further details on how this may be done.

Adding a Second IDE Drive

In common with the ST506 interface, IDE supports a maximum of two drives per bus. However, rather than having separate control and data cables, IDE relies on some signal arbitration taking place between the two drives on the bus; thus the drives must be configured in a "Master / Slave" arrangement. The length of IDE cables, in addition to the spur length (spur length should be kept to <20mm), is critical; the cable distance between adjacent devices on an IDE bus should be kept to between 200 and 250mm, and should definitely not exceed 300mm.

Master or Slave?

Some drive arrangements only work "one way," that is with a given drive as the master and a second given drive as the slave, but not the other way round. If you find a configuration which does not appear to work, first try swapping the cable position and designation of the drives. The table below details the configurations and link settings of the drives we have tested and know to work together:

Master					Slave				
	Link Settings					Link Settings			
Drive	$\overline{\text{HSP}}$	$\overline{\text{C}}$/D	$\overline{\text{DSP}}$	$\overline{\text{ACT}}$	Drive	$\overline{\text{HSP}}$	$\overline{\text{C}}$/D	$\overline{\text{DSP}}$	$\overline{\text{ACT}}$
CP3044 CP30084E CP30126 CP30174E		✔ ✔ ✔ ✔		✔		No slave drive			
CP3044		✔ ✔ ✔ ✔	✔ ✔ ✔ ✔	✔ ✔ ✔ ✔	CP3044 CP30084E CP30126 CP30174E				✔
CP30084E		✔ ✔			CP3044 CP30126				✔
CP30126		✔ ✔ ✔	✔ ✔ ✔		CP3044 CP30084E CP30174E				✔
CP30174E		✔ ✔			CP3044 CP30126				✔
CFS210A		✔			CFS210A				
CFS420A		✔			CFS420A				

Table 1: Known working IDE Drive Configurations

Compatibility Issues
As it currently stands, the IDE specification is not as rigidly defined as the SCSI standard, particularly in the area of timings and their tolerances. Thus it is possible to take two drives and a controller, all of which are compliant with the IDE specification, attach them together on an IDE bus and have sufficient disparity between component timings that the system hangs. Alternatively, some drive combinations can cause one of the drives to "forget"any data (including formatting information) which has previously been saved to it if it is switched off and back on again.

Acorn has only tested the drives listed in the above table, however these are known to work correctly together on both A5000 and Risc PC systems.

If you are planning to make use of a drive which is not listed in the table, there are a few things to pay particular attention to:

* Drive speed - Some drives have slow I/O timings which will work on a machine such as an A3020, which has slower cycle times. A faster Acorn machine such as a Risc PC might have trouble.

* IRQ issues - Some drives have a pull-up resistor on the IRQ line. This is not a good idea - the IRQ line on IDE drives is a tri-state output, and is active high. So disabling the IRQ output on the drive can cause an erroneous IRQ.

* Drive selection - Some IDE drives support selection of the drive via a signal on the IDE connector - the jumper which enables this is the Cable Select, and is often marked as CS on the drive. The Risc PC does not support Cable Select, therefore connecting a drive with this enabled will not work. Similarly, Spindle Sync must be disabled.

Multiple Interfaces on One Machine

Where one flavour of disc interface is already fitted to a machine, either on the motherboard or via an expansion card, there is ordinarily no problem in connecting another interface in the form of an expansion card, if available expansion card space allows. The only exception to this is the Acorn SCSI card; RISC OS will only allow one Acorn SCSI interface to be installed in a machine, although RISC *i*X is capable of differentiating between them. If it is necessary to connect more than six hard drives and / or CD ROM drives, SCSI cards are available from Cumana and Alsystems which allow more than one card to be fitted to a single machine (physical space permitting).

Troubleshooting

Occasionally, such as when power is interrupted during a write operation to a hard disc, disc errors occur. Some error codes are:

From the ST506 Hard Disc controller:

&01	ABT	Command abort has been accepted
&02	IVC	Invalid command
&03	PER	Command parameter error
&04	NIN	Head positioning, disc access or drive check command before SPC has been issued
&05	RTS	TST command after SPC command
&06	NUS	USELD for a selected drive has not been returned
&07	WFL	Write fault (WFLT) detected on the ST506 interface
&08	NRY	Ready signal has been negated

&09	NSC	Seek complete (SCP)was not returned before timeout
&0A	ISE	SEK or disc access command issued during a seek
&0B	INC	Next cylinder address greater than number of cylinders
&0C	ISR	Invalid step rate; highest-speed seek specified in normal seek mode
&0D	SKE	SEK or disc access command issued to drive with seek error
&0E	OVR	Data overrun (memory running slower than drive)
&0F	IPH	Head address greater than number of heads
&10	DEE	Error Correction Code (ECC) detected an error
&11	DCE	CRC error in data area
&12	ECR	ECC corrected an error
&13	DFE	Fatal ECC error in data area
&14	NHT	In CMPD command data mismatched from host and disc
&15	ICE	CRC error in ID field (not generated for ST506)
&16	TOV	ID not found within timeout
&17	NIA	ID area started with an improper address mark
&18	NDA	Missing address mark
&19	NWR	Device write-protected

Errors &01, &03, &04 and &05 should be trapped by ADFS, and hence should never be seen by the user.

From the IDE Hard Disc controller:

&02	IVC	Command aborted by controller
&07	WFL	Write fault
&08	NRY	Drive not ready
&09	NSC	Track 0 not found
&13	DFE	Uncorrected data error
&16	TOV	Sector ID field not found
&17	NIA	Bad block mark detected
&18	NDA	No data address mark
&20		No DRQ when expected
&21		Drive busy when commanded
&22		Drive busy on command completion
&23		Controller did not respond within timeout
&24		Unknown code in error register

From these tables, it is clear that some errors relate to the data on the disc and others to the drive itself; if you see an error other than &13, &16, &17 or &18 from the hard drive, you should refer the problem to your Acorn dealer.

The integrity of the data structures on a disc can be tested by using the *CHECKMAP command; this searches through the directory structure of a disc and compares it to the record of the structure as stored in the directory headers.

If you find that you have any inconsistencies with your data, several products exist which are able to recover as much data as possible from a damaged disc; one of the popular packages is "Archimedes Disc Rescue," available from LookSystems.

Other Standards

In addition to ST506, SCSI and IDE, other drive standards have been developed as extensions and enhancements; in particular, SCSI 2, SCSI 2 Wide, SCSI 2 Fast and EIDE. SCSI 2 protocols are designed to be backwardly compatible with SCSI protocols; many SCSI 2 drives have a link which can be set to enable or disable the variants of SCSI 2, while others can make the translation automatically.Consult the documentation supplied with the drive, or the drive manufacturer, as appropriate refarding compatibility.

EIDE is an enhanced version of IDE designed primarily to handle drives of capacity >2 Gb. Currently EIDE is not supported on our platforms.

Appendix A: Useful Addresses

Disclaimer:
The inclusion or omission of an address does not imply any endorsement of that company or product by Acorn Computers Ltd.

For SCSI and SCSI 2 interfaces

Cumana Ltd
Pines Trading Estate
Broad Street
Guildford
Surrey
GU3 3BH

Tel: 01483 503121
Fax: 01483 503326

Alsystems
47 Winchester Road
Four Marks
Alton
Hants
GU34 5HG

Tel: 01420 561111

For IDE interface expansion cards

HCCS Associates Ltd
575-583 Durham Road
Low Fell
Gateshead
Tyne & Wear
NE9 5JJ

Tel: 0191 487 0760
Fax: 0191 491 0431

ICS (Ian Copestake Limited)
1 Kington Road
Wirral

Merseyside
L48 5ET

Tel: 0151 625 1006
Fax: 0151 625 1007

Beebug Ltd
117 Hatfield Road
St Albans
Hertfordshire
AL1 4JS

Tel: 01727 840303
Fax: 01727 860263

For data recovery software and services:

LookSystems
47 Goodhale Road
Bowthorpe
Norwich
Norfolk
NR5 9AY

Tel: 01603 764114