Inter-Office Memo

To
BOB DRISCAL

From
DAVID BRODSKY DB

Subject
SADI INTERFACE

Date
AUGUST 20, 1981

It is our understanding of the results from the August 11, 1981 interface meeting that the SADI interface will be the ANSI interface. So as not to delay the SA1100E program, we are proceeding using the ANSI interface. If that is not correct then we wasted a long meeting and are back to step one.

DB/bw

cc: H. Meyer
J. Hagerman
P. Lloyd
T. Scooros
A. Chou
R. Bindt
R. LaComble'
M. Feldstein

Inter-Office Memo

To Attendees of Meeting

From Hank Meyer
PMC - 031

Subject Minutes of SADI meeting on Aug. 11, 1981

Date August 24, 1981

ATTENDEES	FUNCTION
Bob Driscal*	Controller Engineering
Don Lowe	Advanced Products Planning
Hank Meyer	Product Management - Controllers
Frank Ng	SA600 Drive Engineering
John Hagerman	Product Management - SA1100
Ray Kong	Controller Engineering
Rich Albert*	Technology Development
Larry Fujitani	Optimem
Al Chou	Rigid Disk Engineering
Dave Brodsky	SA1000/1100 Drive Engineering
Yoshi Narahara	R & D
Jim Dickson	Optimem
Greg Maleski	Optimem
Kenneth Chan*	8" Flexible Disk
Al Kubitz	8" Flexible Disk
Mike Feldstein	Engineering

*Send copies of Rev.7 of ANSI Spec.

MINUTES

The minutes which follow list Action Items, Discussion Items and Accomplishments, in that order.

ACTION ITEMS

1. H. Meyer to provide prioritized list of desired Controllers, with model numbers, for ease of reference.

2. H. Meyer/B. Driscal to prepare Roadmap for Controllers which is independent of Roadmap for drives.

3. SA1100E project to proceed assuming that the device interface for the 1100E will be an ANSI interface. This is in light of discussion items no.'s 2 and 3 below and in light the need for allowing the 1100E project to proceed without hold-up.

4. Assume that SADI is ANSII until further notice and not the Larry Boucher proposed SADI.

DISCUSSION ITEMS

1. The Product Line Manager for Controllers advised that the device interfaces which work with SASI controllers should be the industry standard SA1000 and SA600 Shugart interfaces.

2. The SA1100 Project reported that the SA1100 cannot be caused to reliably record and play-back 2 x 7 code..... the read channel is not wide enough.

3. The SA1100 Project reported that the data separator function must be in the drive electronics to reliably handle 2 x 7 code.

4. In light of No.'s 2 and 3, above, the Product Line Manager for Controllers advised that the first LSI controller implementations should be SA1000, 1100 and 600, using the 144X chip-set and MFM recording only.

5. Optimem Marketing offered that Shugart will probably have to support both the SA1000 and ANSI device interfaces for some period of time. The Product Line Manager for Controllers agreed.

6. The SA1100 project reported that the first 5,000 SA1100's (prior to LSI of device electronics) would have two device electronics boards; hence, there would be no room for a controller board in the form factor of the drive in these models. The 1100E drive would reduce the device electronics to one board, thus making room for the controller board in the form factor of the drive.

7. Optimem reported that it could switch to ANSI; but, it preferred the error protocols of Larry Boucher's SADI.

ACCOMPLISHMENTS

1. Established ANSI as being preferable to "Larry Boucher's SADI" as "the" Shugart Associates Device Interface.

2. Established that Engineering's official position is that the SA1100 cannot be caused to handle 2 x 7 code.

3. Established that the 1100E will have an ANSI device interface pending further notice.

4. Established that the first LSI controller implementation will be for the SA1000/1100 in MFM.

PROPOSED GENERALIZED SADI FOR SMART DRIVES

"SADI", THE SHUGART ASSOCIATES DRIVE INTERFACE, IS A STANDARD INTERFACE CONVENTION BETWEEN A CONTROLLER AND A STRING OF DISK DRIVES. BY ADAPTING A UNIFIORM STANDARD, IT IS MUCH EASIER TO DEVELOP NEW DRIVES AND CONTROLLERS: SHUGART'S PRODUCT DEVELOPMENT TIME IS REDUCED; PRODUCTION TEST PROBLEMS ARE REDUCED; AND THE CUSTOMER CAN ADD NEW DRIVES INTO HIS PRODUCTS WITH MINIMAL HARDWARE AND SOFWARE CHANGES. SADI IS INTENDED FOR USE WITH THE NEW HIGH PERFORMANCE DRIVES BEING DEVELOPED NOW. THE INTENTION OF THE SADI DEFINITION IS TO MEET ALL PRESENT NEEDS AND TO PROVIDE A FLEXIBLE ENOUGH STRUCTURE TO BE ABLE TO ALSO ACCOMMODATE FUTURE PRODUCT REQUIREMENTS. A MAJOR GOAL OF THE INTERFACE SPECIFICATION IS TO BE EASILY IMPLIMENTED WITH MINIMAL HARDWARE AND SOFTWARE. THE USE OF ONE COMMON STANDARD FOR ALL DRIVES ALLOWS THE ECONOMICAL DEVELOPMENT OF CUSTOM LSI CHIPS WHERE APPROPRIATE FOR BOTH THE DRIVE AND THE CONTROLLER SIDES OF THE INTERFACE. "SADI" SHOULD NOT BE CONFUSED WITH "SASI", THE SHUGART ASSOCIATES SYSTEM INTERFACE, WHICH IS A DEFINITION OF THE SIGNALS BETWEEN THE CONTROLLER AND THE HOST COMPUTER.

ALTHOUGH INTENDED FOR USE WITH NEW HIGH PERFORMANCE PRODUCTS, OLDER PRODUCTS COULD BE ADAPTED TO USE SADI. THE SADI SPECIFICATION MAKES VERY FEW ASSUMPTIONS ABOUT THE DRIVES USED WITH IT. THE INTERFACE CAN HANDLE DRIVES OF HIGH OR LOW CAPACITY. THE DATA SEPARATOR CAN BE LOCATED IN THE CONTROLLER OR THE DRIVE. THE INTERFACE CAN ALSO HANDLE BYTE PARALLEL DATA TRANSFERS IF THAT IS NEEDED IN THE FUTURE. ONE OF THE GREAT ADVANTAGES OF SADI IS THAT ADDITIONAL COMMAND AND STATUS SIGNALS CAN BE VERY EASILY INTRODUCED AS REQUIRED BY FUTURE PRODUCTS WITHOUT IMPACTING OLDER DESIGNS AND WITH MINIMAL HARDWARE AND SOFTWARE CHNAGES TO THE CONTROLLER. THE INTERFACE SPECIFICATION IS GENERAL ENOUGH THAT OTHER DEVICES IN ADDITION TO DISK DRIVES CAN BE EASILY CONTROLLED FROM SADI. THE SPECIFICATION PERMITS MORE THAN ONE TYPE OF DEVICE TO BE ON THE INTERFACE AT THE SAME TIME. SADI CAN BE EAISILY IMPLIMENTED IN A MICROPROCESSOR CONTROLLED DEVICE (IT IS UNLIKELY THAT FUTURE HIGH PERFORMANCE DRIVES WILL NOT BE DESIGNED WITH MICROPROCESSOR BASED CONTROL LOGIC); IT COULD ALSO BE IMPLIMENTED WITH SOME COMPLEXITY WITH DESCRETE LOGIC. AN LSI SADI INTERFACE CHIP COULD BE EASILY DEVELOPED. BECAUSE OF THE UNIVERSAL NATURE OF THE SADI SPECIFICATION, IT IS A STRONG CANDIDATE TO BE ACCEPTED AS AN INDUSTRY STANDARD.

THE SADI INTERFACE IS IMPLEMENTED WITH A 50 PIN CONTROL CONNECTOR AND A 20 PIN DATA CONNECTOR. THE SIGNALS ON THE CONTROL CONNECTOR CARRY COMMANDS FROM THE CONTROLLER TO THE DRIVE AND STATUS INFORMATION FROM THE DRIVE BACK TO THE CONTROLLER. THE CONTROL CABLE IS DAISY-CHAINED FROM DRIVE TO DRIVE IN A STRING. THE CONTROL CONNECTOR SIGNALS CONSIST OF 8 "BUS OUT" LINES FROM THE CONTROLLER TO THE DRIVE, 8 "BUS IN" LINES FROM THE DRIVE TO THE CONTROLLER AND 9 CONTROL AND HANDSHAKING LINES. THE DATA CONNECTOR CARRIES INTERRUPT SIGNALS FROM THE DRIVE TO THE CONTROLLER AND SERIAL DATA AND TIMING CLOCK SIGNALS. THE DATA CABLE CAN BE EITHER A RADIAL OR A DAISY-CHAIN CONNECTION DEPENDING ON THE DRIVE TYPE AND DATA RATE. THE DATA CONNECTOR SIGNALS ARE SIMILAR TO THOSE USED ON PRESENT SHUGART RIGID DISK PRODUCTS.

SADI CONTROL OPERATIONS DEPEND ON THE USE OF 3 "MODE SELECT" LINES TO DEFINE HOW THE "BUS OUT" AND "BUS IN" LINES BETWEEN THE DRIVE AND CONTROLLER ARE TO BE USED IN THAT COMMAND SEQUENCE. THE CONTROLLER BEGINS A COMMAND BY SETTING THE "MODE SELECT" BITS AND PLACING THE PROPER COMMAND BITS ON THE "BUS OUT" LINES AND ACTIVATING THE "MODE ENABLE" HANDSHAKE LINE. THE DRIVE RESPONDS BY TAKING THE DATA, PLACING THE PROPER STATUS DATA ON THE "BUS IN" LINES AND ACTIVATING THE "ACKNOWLEDGE" HANDSHAKE LINE. THE CONTROLLER ENDS THE SEQUENCE BY DEACTIVATING "MODE ENABLE". THE USE OF 8 MODES WITH 16 LINES PER MODE GIVES 256 BITS OF COMMAND AND STATUS INFORMATION DIRECTLY; SINCE COMMANDS CAN CAUSE FURTHER MULTIPLEXING OF THE LINES, A VIRTUALLY UNLIMITTED NUMBER OF SIGNALS IS POSSIBLE.

SADI DATA OPERATIONS USE A "DATA ENABLE" HANDSHAKE LINE FROM THE CONTROLLER TO COMMAND A DATA TRANSFER AND "READ GATE" AND "WRITE GATE" LINES FROM THE CONTROLLER SPECIFY THE DIRECTION OF THE DATA MOVEMENT. THE DATA IS ACTUALLY TRANSMITTED OVER THE SERIAL DATA LINES ON THE DATA CONNECTOR ALONG WITH NECESSARY CLOCK SIGNALS. ANY DRIVES DEVELOPED IN THE NEAR TERM WILL USE SERIAL DATA TRANSFERS, HOWEVER, THE INTERFACE CAN SUPPORT THE USE OF PARALLEL DATA TRANSFERS USING THE "BUS OUT" AND "BUS IN" LINES IF REQUIRED AT A LATER DATE. THE INTERFACE MAKES NO ASSUMPTIONS ABOUT THE DATA FORMAT USED, ALTHOUGH A GIVEN DRIVE CAN BE SPECIFIED TO USE ONLY A PARTICULAR FORMAT (MFM, 2:7, ETC.).

WHEN NO COMMAND IS IN PROCESS, THE DRIVE PLACES STATUS INFORMATION ON THE "BUS IN" LINES. WHEN SELECTED, A DRIVE WILL INDICATE ITS PRESNENCE ON THE INTERFACE BY ACTIVATING THE "ON LINE" SIGNAL. THE INTERFACE ALSO PROVIDES TWO INTERRUPT LINES ALLOWING THE DRIVE, EVEN IF NOT SELECTED, TO ASYNCRONOUSLY ALERT THE CONTROLLER OF ITS NEED FOR SERVICE.

GENERALIZED SADI SIGNALS:

50 PIN CONTROL CONNECTOR: (NOTE: ALL SADI CONTROL LINES ARE ACTIVE LOW.)

MODE SEL 1
MODE SEL 2
MODE SEL 3
MODE ENABLE
ACKNOWLEDGE
ON LINE
READ GATE
WRITE GATE
DATA ENABLE

	status	MODE 0	MODE 1	MODE 2	MODE 3	MODE 4	MODE 5
BUS OUT 7	n/a	SELECT 8	RESET FAULT	CYL 128	CYL 32768	HD 128 (HD LD)	OFFSET IN
BUS OUT 6	n/a	SELECT 7	DISPLAY FAULT	CYL 64	CYL 16384	HEAD 64	OFFSET 1/4
BUS OUT 5	n/a	SELECT 6	SEEK START	CYL 32	CYL 8192	HEAD 32	OFFSET 1/8
BUS OUT 4	n/a	SELECT 5	RECAL	CYL 16	CYL 4096	HEAD 16	OFFSET 1/16
BUS OUT 3	n/a	SELECT 4	OFF LINE SEEK	CYL 8	CYL 2048	HEAD 8	OFFSET 1/32
BUS OUT 2	n/a	SELECT 3	COMMAND 3	CYL 4	CYL 1024	HEAD 4	OFFSET 1/64
BUS OUT 1	n/a	SELECT 2	COMMAND 2	CYL 2	CYL 512	HEAD 2	OFFSET 1/128
BUS OUT 0	n/a	SELECT 1	COMMAND 1	CYL 1	CYL 256	HEAD 1	OFFSET 1/256

	no mode	SELECT	COMMANDS	LOW CYLINDER	HIGH CYLINDER	HEAD SELECT	OFFSET
US IN 7	READY	DEVICE ID 8	READY / FL4	READY	READY	READY	READY
BUS IN 6	FAULT	DEVICE ID 7	FAULT / FL2	FAULT	FAULT	FAULT	FAULT
BUS IN 5	SEEK COMPLETE	DEVICE ID 6	SK COMP / FL1	SEEK COMPLETE	SEEK COMPLETE	SEEK COMPLETE	SEEK COMPLETE
BUS IN 4	INDEX	DEVICE ID 5	INDEX	INDEX	INDEX	INDEX	INDEX
BUS IN 3	SECTOR	DEVICE ID 4	SECTOR	SECTOR	SECTOR	SECTOR	SECTOR
BUS IN 2	STATUS BIT 3	DEVICE ID 3	STATUS BIT 3	STATUS BIT 3	STATUS BIT 3	STATUS BIT 3	STATUS BIT 3
BUS IN 1	STATUS BIT 2	DEVICE ID 2	STATUS BIT 2	STATUS BIT 2	STATUS BIT 2	STATUS BIT 2	STATUS BIT 2
BUS IN 0	STATUS BIT 1	DEVICE ID 1	STATUS BIT 1	STATUS BIT 1	STATUS BIT 1	STATUS BIT 1	STATUS BIT 1

	status	MODE 0	MODE 1	MODE 2	MODE 3	MODE 4	MODE 5

THE DEFINITIONS OF SIGNALS IN MODES 6 AND 7 ARE DEVICE DEPENDENT.

20 PIN DATA CONNECTOR:

INTERRUPT 1 (ACTIVE LOW, OPEN COLLECTOR)
INTERRUPT 2 (ACTIVE LOW, OPEN COLLECTOR)
+READ DATA / +SEP DATA
-READ DATA / -SEP DATA
+READ CLOCK / +PLO / +SEP CLOCK
-READ CLOCK / -PLO / -SEP CLOCK
+WRITE DATA
-WRITE DATA
+WRITE CLOCK
-WRITE CLOCK

SADI SIGNAL DEFINITIONS:

GENERAL CONTROL SIGNALS:

MODE SEL x — SELECTS THE COMMAND CURRENT MODE TO BE ACTIVIATED BY "MODE ENABLE".
THE MODE FUNCTIONS ARE:

MODE 0	SELECT
MODE 1	COMMANDS
MODE 2	LOW BYTE OF NEW CYLINDER
MODE 3	HIGH BYTE OF NEW CYLINDER (LARGER CAPACITY DRIVES ONLY)
MODE 4	HEAD SELECT
MODE 5	OFFSET (MAY NOT BE RECOGNIZED BY ALL DRIVE TYPES)
MODE 6	DRIVE DEPENDENT FUNCTION
MODE 7	DRIVE DEPENDENT FUNCTION

MODE ENABLE — INDICATES CONTROLLER HAS PLACED VALID DATA ON "MODE SEL" AND "BUS OUT" LINES.
THIS LINE IS USED FOR COMMAND HANDSHAKING.

ACKNOWLEDGE — INDICATES THE DRIVE HAS RESPONDED TO THE CURRENT COMMAND OR DATA TRANSFER REQUEST.
THIS LINE IS USED FOR CONTROL AND DATA HANDSHAKING.

ON LINE — INDICATES THAT A DRIVE IS SELECTED AND IS SUPPLYING SIGNALS TO THE INTERFACE.

READ GATE — COMMANDS THE DRIVE READ/WRITE CIRCUITS TO READ.

WRITE GATE — COMMANDS THE DRIVE READ/WRITE CIRCUITS TO WRITE.

DATA ENABLE — ENABLES THE DRIVE READ/WRITE CIRCUITS TO TRANSFER DATA. THIS LINE IS USED FOR DATA HANDSHAKING.
DEPENDING ON THE DRIVE TYPE, EITHER SERIAL TRANSFER USING "WRITE DATA" AND "READ DATA" LINES OR
PARALLEL TRANSFER USING THE "BUS OUT" AND "BUS IN" LINES MAY BE USED.

BUS OUT x — SIGNALS FROM CONTROLLER TO DRIVE. EACH LINE'S INTERPRETATION IS SET BY THE CURRENT MODE.
IF THE DRIVE USES PARALLEL DATA TRANSFER, THESE LINES CARRY DATA TO THE DRIVE WHEN
"DATA ENABLE" AND "WRITE GATE" ARE ACTIVE.

BUS IN x — SIGNALS FROM DRIVE TO CONTROLLER. EACH LINE'S INTERPRETATION IS SET BY THE CURRENT MODE.
IF "MODE ENALBE" AND "DATA ENABLE" ARE INACTIVE, THESE LINES DISPLAY DRIVE status INFORMATION.
IF THE DRIVE USES PARALLEL DATA TRANSFER, THESE LINES CARRY DATA FROM THE DRIVE WHEN
"DATA ENABLE" AND "READ GATE" ARE ACTIVE.

DATA CONNECTOR SIGNALS:

INTERRUPT x — INTERRUPT REQUEST FROM THE DRIVE TO THE CONTROLLER. INTERRUPTS CAN BE GENERATED WHEN THE DRIVE IS NOT SELECTED. THESE LINES ARE OPEN-COLLECTOR, ACTIVE LOW LEVEL TO ALLOW "WIRE-ORing" INTERRUPTS FROM ALL DRIVES AT THE CONTROLLER.

READ DATA — SERIAL DATA READ FROM THE DRIVE. IF THE DRIVE LACKS AN INTERNAL DATA SEPARATOR THIS LINE CARRIES RAW READ DATA. IN PARALLEL TRANSFER MODE THIS LINE CAN BE USED FOR A PARITY SIGNAL FOR THE "BUS IN" LINES FROM THE DRIVE.

SEP DATA — DATA SIGNALS SEPATATED FROM THE DATA STREAM IF THE DRIVE HAS AN INTERNAL DATA SEPARATOR. THIS SIGNAL, IF PRESENT, IS GENERATED BY THE DRIVE.

READ CLOCK — CLOCK SIGNAL SYNCRONIZED WITH THE TIMING OF DATA READ FROM THE DISK IF THE DRIVE GENERATES SUCH A SIGNAL. THIS LINE MAY BE USED IN BOTH SERIAL AND PARALLEL DATA TRANSFER MODES.

PLO — PHASE LOCKED OCSILLATOR CLOCK SIGNAL GENERATED BY THE DRIVE IF THE DRIVE HAS A PLO CIRCUIT.

SEP CLOCK — CLOCK SIGNALS SEPARATED FROM THE DATA STREAM IF THE DRIVE HAS AN INTERNAL DATA SEPARATOR.

IF THE DRIVE DOES NOT GENERATE A "READ CLOCK", "PLO", OR "SEP CLOCK" SIGNAL, THIS LINE IS LEFT OPEN.

WRITE DATA — SERIAL DATA SUPPLIED BY THE CONTROLLER TO BE WRITTEN TO THE DRIVE. IN PARALLEL TRANSFER MODE THIS LINE CAN BE USED FOR A PARITY SIGNAL FOR THE "BUS OUT" LINES FROM THE CONTROLLER.

WRITE CLOCK — CLOCK SIGNAL FROM THE CONTROLLER THAT IS SYNCRONIZED WITH TIMING OF DATA TO BE WRITTEN ON THE DISK. IF THE DRIVE DOES NOT REQUIRE SUCH A SIGNAL, THE LINE IS LEFT OPEN. THIS LINE MAY BE USED IN BOTH SERIAL AND PARALLEL DATA TRANSFER MODES.

NOTE: THE EXACT USAGE OF THE "READ DATA / SEP DATA", "READ CLOCK / PLO / SEP CLOCK", "WRITE DATA", AND "WRITE CLOCK" LINES MUST BE DETERMINED FOR EACH DRIVE TYPE DEPENDING ON THE PRESENCE AND NATURE OF A DATA SEPARATOR IN THE DRIVE. THE SIGNAL DIRECTIONS WILL ALWAYS BE THE SAME: "READ DATA / SEP DATA" AND "READ CLOCK / PLO/ SEP CLOCK" ARE SUPPLIED BY THE DRIVE; "WRITE DATA" AND AND "WRITE CLOCK" ARE SUPPLIED BY THE CONTROLLER. THE DATA TRANSFER LINES ARE ALWAYS DIFFERENTIAL PAIRS.

CONTROL HANDSHAKING:

THE SEQUENCE OF OPERATIONS OF THE "MODE ENABLE" AND "ACKNOWLEDGE" LINE IS AS FOLLOWS:

1. THE CONTROLLER PLACES VALID DATA ON THE "BUS OUT" AND "MODE SEL" LINES.
2. THE CONTROLLER ACTIVES THE "MODE ENABLE" LINE. AT THIS TIME "BUS IN" STATUS IS ASSUMED TO NO LONGER BE VALID.
3. THE DRIVE PLACES VALID DATA ON THE "BUS IN" LINES REPLACING STATUS INFORMATION.
4. THE DRIVE THEN ACTIVATES THE "ACKNOWLEDGE" LINE.

AFTER THE CONTROLLER HAS RECEIVED THE "BUS IN" DATA:

5. THE CONTROLLER DE-ACTIVATES THE "MODE ENABLE" LINE.
6. THE DRIVE RESTORES VALID STATUS INFORMATION ON "BUS IN".
7. THE DRIVE THEN DE-ACTIVATES THE "ACKNOWLEDGE" LINE.

THE EXACT TIMING OF THE SIGNALS IS A FUNCTION OF THE PARTICULAR DRIVE AND CONTROLLER DESIGN AND THE COMMAND BEING EXECUTED.

DATA TRANSFER HANDSHAKING:

THE SEQUENCE OF OPERATIONS OF THE "DATA ENABLE" AND "ACKNOWLEDGE" LINE IS AS FOLLOWS:

1. THE CONTROLLER ACTIVES THE "DATA ENABLE" LINE. IF PARLALLEL DATA TRANSFER IS USED, THE STATUS IMFORMATION IS ASSUMED TO NO LONGER BE VALID AT THIS TIME.
2. THE DRIVE SETS UP TO TRANSFER DATA.
3. THE DRIVE THEN ACTIVATES THE "ACKNOWLEDGE" LINE.

THE DATA IS TRANSFERED AS DICTATED BY THE "READ GATE" AND "WRITE GATE" LINES.

AFTER THE DATA HAS BEEN TRANSFERRED:

5. THE CONTROLLER DE-ACTIVATES THE "DATA ENABLE" LINE.
6. THE DRIVE RESTORES VALID STATUS INFORMATION ON "BUS IN".
7. THE DRIVE THEN DE-ACTIVATES THE "ACKNOWLEDGE" LINE.

BUS OUT SIGNALS:

SELECT x	DRIVE SELECT LINES. SELECT LINES ARE COMPARED TO JUMPERS IN THE DRIVE. UNUSED BITS FOR A GIVEN DRIVE MUST BE 0.
RESET FAULT	CLEARS A PREVIOUSLY SET FAULT CONDITION. THE "FAULT" LINE IS SET INACTIVE AND THE FAULT CODE IS SET TO 0 (NO FAULT).
DISPLAY FAULT	COMMANDS THE "BUS IN 7" (READY), "BUS IN 6" (FAULT) AND "BUS IN 5" LINES TO DISPLAY A CODE IDENTIFYING THE TYPE OF THE LAST FAULT FOUND. THE LINES WILL RETURN TO THEIR NORMAL status MEANING AT THE END OF THE COMMAND (AFTER "MODE ENA" GOES INACTIVE).
SEEK START	COMMANDS THE DRIVE TO BEGIN A SEEK TO THE PREVIOUSLY SPECIFIED CYLINDER.
RECAL START	COMMANDS THE DRIVE TO PERFORM A RECAL (RETURN TO TRACK 000) OPERATION. A RECAL IS REQUIRED TO RECOVER FROM A POSITIONER ERROR.
OFF LINE SEEK	COMMANDS THE DRIVE TO FIRST DESELECT ITSELF BEFORE SEEKING OR RECALING. ONLY VALID IN COMBINATION WITH "SEEK START" OR "RECAL".
COMMAND x	DRIVE DEPENDENT ADDITIONAL COMMAND BITS. THEY MAY COMMAND ADDITIONAL MEANINGS FOR THE OTHER "BUS OUT" LINES AND THE "BUS IN" LINES.
CYL x	CYLINDER SPECIFICATION FOR NEXT SEEK. "CYL 1" THROUGH "CYL 128" (MODE 2) AND "CYL 256" THROUGH "CYL 32768" (MODE 3) MUST BE SET UP BEFORE A MODE 1 "SEEK START" COMMAND IS ACTIVATED. FOR DRIVES WITH LESS THAN 256 CYLINDERS, MODE 3 IS UNUSED. MODE 2 AND MODE 3 VALUES ARE RETAINED UNTIL NEW VALUES ARE COMMANDED. A DESIRED NEW CYLINDER IS SPECIFIED AS AN ABSOLUTE CYLINDER NUMBER.
HEAD LOAD	LOAD THE DRIVE HEADS. THIS LINE WILL BECOME "HEAD 128" IF THE DRIVE DOES NOT REQUIRE A HEAD LOAD FUNCTION. HEAD LOAD SETTLING TIME IS SIGNALLED BY THE "SEEK COMPLETE" LINE GOING INACTIVE UNTIL THE HEADS ARE SETTLED.
HEAD x	HEAD SELECTION. UNUSED BITS FOR A GIVEN DRIVE MUST BE 0. MODE 4 HEAD SELECT VALUES ARE RETAINED UNTIL NEW VALUES ARE COMMANDED.
OFFSET IN	SPECIFIES THAT AN OFFSET SHOULD BE MADE TOWARD THE SPINDLE (IN).
OFFSET x	SPECIFIES THE SIZE OF AN OFFSET IN UNITS OF TRACK PITCH. A VALUE OF 0 RETURNS THE HEADS TO THE TRACK CENTER. OFFSET SETTLING TIME IS SIGNALLED BY THE "SEEK COMPLETE" LINE GOING INACTIVE UNTIL THE HEADS ARE SETTLED. MODE 5 OFFSET VALUES ARE RETAINED UNTIL NEW VALUES ARE COMMANDED.

BUS IN SIGNALS:

DEVICE ID x — A UNIQUE IDENTIFICATION CODE FOR EACH DIFFERENT TYPE OF DRIVE IS PLACED ON THESE LINES WHEN THE DRIVE IS SELECTED. THE CODE SPECIFIES THE TYPE AND CAPACITY CONFIGURATION OF THE DRIVE AND IMPLIES HOW THE DRIVE USES THE SADI SIGNALS. THE CODE IS SPECIFIED WHEN THE DRIVE IS DESIGNED. SOME BITS MAY BE CHANGED DYNAMICALLY TO INDICATE DISK FORMAT OR FRONT PANEL CONTROL SETTINGS.

FLT x — A CODE DISPLAYING THE TYPE OF THE LAST FAULT DETECTED. THESE LINES ARE ONLY INTERPRETTED THIS WAY WHEN "DISPLAY FAULT" IS ACTIVE IN MODE 1.

READY — ACTIVE WHEN THE DRIVE IS READY TO FUNCTION. ON DRIVES WITH REMOVABLE MEDIA, "READY" INACTIVE INDICATES NO DISK IN THE DRIVE. THIS LINE BECOMES FAULT CODE "FLT4" WHEN "DISPLAY FAULT" IS ACTIVE IN 'MODE 1'.

FAULT — ACTIVE WHEN THE DRIVE HAS DETECTED A FAULT CONDITION:

1. INVALID BUS COMMANDS OR SIGNALS
2. CIRCUIT FAILURES

THIS LINE BECOMES FAULT CODE "FLT2" WHEN "DISPLAY FAULT" IS ACTIVE IN 'MODE 1'.

SEEK COMPLETE — THE SPECIFIED MOTION HAS BEEN COMPLETED OR HAS BEEN ABORTED DUE TO A FAULT. THIS LINE BECOMES FAULT CODE "FLT1" WHEN "DISPLAY FAULT" IS ACTIVE IN 'MODE 1'.

INDEX — DISK INDEX DETECTED. FOR SOME DRIVES THIS LINE WILL ONLY BE VALID WHEN "READY" IS ACTIVE. THE MINIMUM PULSE WIDTH IS 1.0 microSECOND.

SECTOR — DISK HARD SECTOR DETECTED. INACTIVE FOR SOFT SECTORED FORMATS. FOR SOME DRIVES THIS LINE WILL ONLY BE VALID WHEN "READY" IS ACTIVE. THE MIMIMUM PULSE WIDTH IS IS 1.0 microSECOND.

STATUS BIT x — DRIVE DEPENDENT ADDITIONAL STATUS BITS. UNUSED BITS MUST BE LEFT INACTIVE. "STATUS BIT 1" IS USED FOR CAPACITY OR FORMAT DEPENDENT STATUS IF THE DRIVE HAS THAT FEATURE. "STATUS BIT 2" IS USED FOR 'WRITE PROTECT' STATUS IF THE DRIVE HAS THAT FEATURE.

STATUS BITS:

THE INTERPETATION OF THE THREE STATUS BITS ("FAULT", "READY", "SEEK COMPLETE") IS AS FOLLOWS:

"READY"	"FAULT"	"SEEK COMP"	
0	0	0	NOT READY. ONLY SELECT COMMANDS ACCEPTED.
0	0	1	------- (THIS CONDITION NEVER HAPPENS.)
0	1	0	FAULT IN START-UP SEQUENCE. ONLY SELECT COMMANDS ACCEPTED.
0	1	1	------- (THIS CONDITION NEVER HAPPENS.)
1	0	0	MOTION IN PROCESS; SETTLING TIME NOT COMPLETED.
1	0	1	NORMAL CONDITION. READY FOR NEXT COMMAND.
1	1	0	------- (THIS CONDITION NEVER HAPPENS.)
1	1	1	FAULT HAS BEEN DETECTED. COMMANDS CAN BE ACCEPTED.

FAULT CODES:

FL4, FL2, FL1 THESE LINES INDICATE THE LAST DETECTED FAULT CONDITION WHEN "DISPLAY FAULT" IS ACTIVE.
FOR DISK DRIVES THE CODING IS AS FOLLOWS:

CODE	FL4	FL2	FL1	FAULT
0	0	0	0	NO FAULT DETECTED
1	0	0	1	INVALID MODE
2	0	1	0	INVALID COMMAND
3	0	1	1	INVALID CYLINDER OR HEAD NUMBER
4	1	0	0	INVALID READ/WRITE COMMAND
5	1	0	1	READ/WRITE HARDWARE FAULT
6	1	1	0	POSITIONER HARDWARE FAULT
7	1	1	1	CONTROL CIRCUIT FAULT

FAULT CODE 0 NO FAULTS HAVE OCCURRED.
FAULT CODE 1 INVALID MODE: UNDEFINED MODE SELECTED. ANY MODE BUT SELECT (MODE 0) WHEN "READY" IS NOT ACTIVE.
FAULT CODE 2 INVALID COMMAND WITHIN A MODE. (EG. "SEEK" AND "RECAL" TOGETHER IN MODE 1, ETC.).
FAULT CODE 3 CYLINDER NUMBER OR HEAD NUMBER SPECIFIED BEYOND THE DRIVE'S CAPACITY.
FAULT CODE 4 INVALID R/W COMMAND: "MODE ENABLE" AND "DATA ENABLE" AT THE SAME TIME; "READ GATE" OR "WRITE GATE" WITHOUT "DATA ENABLE"; "READ GATE" OR "WRITE GATE" WITHOUT THE HEADS LOADED; "READ GATE" AND "WRITE GATE" AT THE SAME TIME; "WRITE GATE" WHEN THE DRIVE IS WRITE PROTECTED; ETC. READ / WRITE OPERATIONS MAY BE INHIBITED UNTIL THE FAULT IS RESET.
FAULT CODE 5 R/W HARDWARE ERROR: THE READ/WRITE CIRCUITS HAVE FAILED. READ /WRITE OPERATIONS MAY BE INHIBITED UNTIL THE FAULT IS RESET.
FAULT CODE 6 POSITIONER HARDWARE ERROR: THE POSITIONER CIRCUITS HAVE FAILED. A RECAL WILL USUALLY BE REQUIRED TO RECOVER FROM A POSITIONER FAULT.
FAULT CODE 7 CONTROL FAULT: THE CONTROL CIRCUITS HAVE FAILED. IF THIS FAULT OCCURS, THE DRIVE INTERFACE MAY BECOME UNPREDICATBLE.

NOTES ON GENERALIZED SADI:

1. ALL SADI CONTROL LINES ARE ACTIVE LOW TTL LEVELS. "BUS IN", "ON LINE", AND "ACKNOWLEDGE" LINES ARE DRIVEN BY TRI-STATE DRIVERS AND ARE ENABLED ONLY WHEN THE DRIVE IS SELECTED. THE "INTERRUPT x" LINES ARE OPEN-COLLECTOR ACTIVE LOW TTL LEVELS AND MAY BE ENABLED EVEN WHEN THE DRIVE IS NOT SELECTED. THE "READ DATA" AND "READ CLOCK" LINES ARE DIFFERENTIAL PAIRS AND ARE ENABLED ONLY WHEN SELECTED.

2. DRIVE SELECTION OCCURS IN 'MODE 0' WHEN THE "SELECT x" LINES MATCH THE SELECT CONFIGURATION JUMPERS IN THE DRIVE. THEREFORE EITHER A 1-OF-256 SELECT DECODING OR A LINE-PER-DRIVE SELECT DECODING CAN BE USED AS DESIRED BY THE SYSTEM DESIGNER. THE "ON LINE" SIGNAL INDICATES THAT A DRIVE IS SELECTED.

3. ONLY A SELECTED DRIVE RETURNS "ACKNOWLEDGE", "ON LINE", AND "BUS IN" STATUS. A DESLECETED DRIVE (INCLUDING ONE DESELECTED BY THE CURRENT COMMAND) DOES NOT RESPOND WITH "ACKNOWLEDGE" AND MUST DISCONNECT ITSELF FROM THE SADI BUS WITHIN 100 microSECONDS. WHEN SELECTED, A DRIVE MUST DELAY AT LEAST 100 microSECONDS BEFORE ENABLING ITS SADI BUS DRIVERS TO ALLOW ANY DESELECTED DRIVE TO GET OFF THE BUS. DURING SOME OPREATIONS, PARTICULARLY RECALS AND SEEKS, SOME DRIVES MAY NOT BE ABLE TO MONITOR THE SADI BUS FOR SELECT COMMANDS. THEREFORE SELECT COMMANDS SHOULD NOT BE GIVEN WHEN SUCH AN OPERATION IS IN PROCESS AS THE DRIVE MAY NOT DESELECT AND COULD THUS CAUSE BUS CONTENTIONS. THE "OFF LINE SEEK" COMMAND SHOULD BE USED FOR OVERLAPPED SEEKING.

4. WHEN "MODE ENABLE" AND "DATA ENABLE" ARE BOTH INACTIVE, THE "BUS OUT" LINES ARE IGNORED BY THE DRIVE AND THE "BUS IN" LINES DISPLAY status INFORMATION. IF THE DRIVE DOES NOT USE PARALLEL DATA TRANSFER, THE "BUS OUT" LINES ARE IGNORED AND THE "BUS IN" LINES ALSO DISPLAY THE status INFORMATION WHEN "DATA ENABLE" IS ACTIVE.

5. SEEK AND RECAL OPERATIONS TAKE PLACE AFTER THE COMPLETION OF THE COMMAND HANDSHAKE ("ACKNOWLEDGE" HAS BEEN DEACTIVATED IN RESPONSE TO THE CONTROLLER DEACTIVATING "MODE ENABLE"). THE "SEEK COMPLETE" STATUS BIT INDICATES WHEN THE HEADS ARE SETTLED ON THE NEW CYLINDER.

6. A SEEK OR RECAL COMMAND WILL RESET THE "FAULT" STATUS BIT AND SET THE FAULT CODE TO 0 (NO FAULT) UNLESS A NEW FAULT IS DETECTED DURING THE COMMANDS'S EXECUTION. A SEEK FAULT IS INDICATED BY BOTH "FAULT" STATUS AND "SEEK COMPLETE" STATUS ACTIVE. A "RESET FAULT" COMMAND LEAVES "SEEK COMPLETE" ACTIVE EVEN THOUGH THE HEADS MAY NOT BE PROPERLY POSITIONED.

7. IF THE "OFF LINE SEEK" BIT IS ACTIVE IN ADDITION TO THE "SEEK START" OR "RECAL" BIT, THE DRIVE WILL PERFORM AN OFF-LINE SEEK OR AN OFF-LINE RECAL: AFTER COMPLETING THE COMMAND HANDSHAKE, THE DRIVE DESELECTS ITSELF BEFORE STARTING THE MOTION.

8. MOTION TO THE SPECIFIED OFFSET WITHIN THE CURRENT CYLINDER IS MADE AT THE TIME 'MODE 5' IS ENABLED. THE SPECIFIED OFFSET WILL REMAIN IN EFFECT UNTIL A NEW OFFSET OR A SEEK IS COMMANDED. IF "OFFSET IN" IS ACTIVE THE HEADS ARE MOVED TOWARD THE SPINDLE; OTHERWISE THE MOTION IS AWAY FROM THE SPINDLE. THE MOTION IS SPECIFIED AS n/256 OF THE A CYLINDER PITCH. THE "SEEK COMPLETE" STAUTS BIT WILL BE INACTIVE UNTIL THE MOTION IS COMPLETED. WRITING MAY BE INHIBITED IN THE DRIVE WHEN THE OFFSET IS NOT ZERO.

9. IF A FAULT IS DETECTED WHEN "DATA ENABLE" IS ACTIVATED OR THE "FAULT" STATUS IS ACTIVE, WRITE OPERATIONS MAY BE INHIBITTED IN THE DRIVE UNTIL THE FAULT IS RESET.

10. FOR ALL DRIVES WITH REMOVABLE MEDIA AND TRACK FOLLOWING OR EMBEDDED SERVOS, AN AUTOMATIC RECAL IS PERFORMED AS PART OF THE START UP SEQUENCE WHEN THE MEDIA IS LOADED. OTHER DRIVES MIGHT NOT RECAL AS PART OF THE START UP SEQUENCE. THE FAULT STATUS WILL BE RESET AND "READY" MADE ACTIVE AT THE COMPLETION OF THE STAKT UP SEQUENCE UNLESS A FAULT IS DETECTED, IN WHICH CASE THE DRIVE WILL SET SET "FAULT" STATUS ACTIVE AND LEAVE "READY" STATUS INACTIVE.

11. IF A POSITIONER FAULT (CODE 6) OCCURS, A RECAL MAY BE REQUIRED TO RE-ENABLE THE POSITIONER SYSTEM.

12. DRIVES SHOULD PERFORM A SELF TEST AT POWER-ON-RESET. ANY DRIVE THAT FAILS THIS SELF TEST SHOULD NOT RESPOND TO THE SADI AT ALL. THE "FAULT" TEST POINT ON THE DRIVE SHOULD BE ACTIVATED.

NOTES ON FURTHER EXPANDING SADI:

1. ALL SADI DEVICES USE 'MODE 0' FOR SELECT AND 'MODE 1' FOR COMMANDS. "DEVICE ID x" IS ALWAYS DISPLAYED IN 'MODE 0'. ALL DEVICES WILL RESPOND TO THE "RESET FAULT" (BUS OUT 7) AND "DISPLAY FAULT" (BUS OUT 6) COMMANDS AND GENERATE THE "READY" AND "FLT4" (BUS IN 7); "FAULT" AND "FLT2" (BUS IN 6); AND "FLT1" (BUS IN 5) STATUS SIGNALS.

2. A GIVEN DRIVE NEED NOT USE ALL THE SERIAL DATA LINES. THE UNUSED LINES SHOULD BE LEFT OPEN. ALL DRIVES USING SERIAL DATA TRANSFER WILL AS A MINIMUM USE THE "READ DATA" AND "WRITE DATA" LINES.

3. THE USE OF 'MODE 6' AND 'MODE 7', THE "COMMAND x" LINES IN 'MODE 1' AND "STATUS x" LINES ARE LEFT TO THE DISCRETION OF THE DRIVE DESIGNER TO ALLOW EASY EXPANSION WITHIN THE SADI FRAMEWORK. IF THE MODES ARE NOT USED THEY ARE UNDEFINED. IF THE "COMMAND x" LINES ARE UNUSED, THEY MUST BE SET INACTIVE. THE "STATUS x" LINES SHOULD BE SET INACTIVE IF NOT USED.

4. THE "INTERRUPT x" LINES CAN BE DEFINED TO HAVE FIXED MEANING IN HARDWARE OR THEIR MEANINGS CAN BE SET BY A 'MODE 6' OR 'MODE 7' COMMAND OR BY THE USE OF A "COMMAND x" LINE IN 'MODE 1'. NO ACTION IS REQUIRED IF THE DRIVE DOES NOT USE INTERRUPTS; THE "INTERRUPT x" LINES ARE THEN JUST LEFT OPEN.

5. A DRIVE MAY BE DESIGNED TO SPECIFY SEEKS IN TERMS OF DISTANCE AND DIRECTION. IN THAT CASE THE MOST SIGNIFICANT "CYL x" BIT OF THE MOST SIGNIFICANT BYTE OF THE CYLINDER SETTING MODES, WILL BE DEFINED AS "SEEK IN". WHEN ACTIVE, "SEEK IN" SPECIFIES A SEEK TOWARD THE SPINDLE. IF ALL BITS OF ALL CYLINDER SETTING MODES ARE NEEDED, THE "SEEK IN" COMMAND CAN AS AN OPTION USE A "COMMAND x" LINE.

6. A DRIVE MAY BE DESIGNED TO SPECIFY OFFSET AND HEAD SELECT AS APPLYING TO THE NEXT SEEK RATHER THAN THE CURRENT CYLINDER. THIS WOULD ALLOW A CONTROLLER TO SEQUENCE DOWN THROUGH THE POSITION DEFINING MODES (OFFSET, THEN HEAD, THEN CYLINDER) BEFORE GIVING THE "SEEK START" COMMAND. IN SUCH A CASE A "SEEK START" WOULD BE REQUIRED TO CHANGE HEADS OR EXECUTE AN OFFSET WITHIN THE CURRENT CYLINDER. (SINCE CYLINDER, HEAD, AND OFFSET VALUES ARE RETAINED UNTIL MODIFIED, THE UNCHANGED VALUES NEED NOT BE RESPECIFIED).

7. A DRIVE MAY NOT HANDLE SETTLING TIMING INTERNALLY FOR ALL FUNCTIONS (SEEK, RECAL, HEAD LOAD OR OFFSET). IN THOSE CASES THE "SEEK COMPLETE" LINE WILL NOT BE PULSED AND THE TIMING WILL BECOME A CONTROLLER FUNCTION.

8. INHERENT IN THE SADI DEFINITION IS THE POSSIBILITY OF USING PARALLEL DATA TRANSFERS. "READ GATE", "WRITE GATE", AND "DATA ENABLE" ARE USED NORMALLY. TIMING SIGNALS, IF REQUIRED ARE TRANSMITTED ON THE "READ CLOCK" AND "WRITE CLOCK" DATA CONNECTOR SIGNALS. IF THE DRIVE USES PARALLEL DATA TRANSFER, THE "BUS IN" AND "BUS OUT" LINES WILL CARRY DATA. IF PARITY INFORMATION IS REQUIRED, THE "READ DATA" LINE CAN BE USED AS PARITY FOR THE "BUS IN" LINES FROM THE DRIVE AND THE "WRITE DATA" LINE CAN BE USED AS PARITY FOR THE "BUS OUT" LINES FROM THE CONTROLLER. THE "READ GATE" AND "WRITE GATE" WILL CONTROL WHICH DIRECTION VALID DATA IS BEING TRANSMITTED. TIMING OF THE TRANSFERS CAN BE ACCOMPLISHED BY PULSING THE GATE LINES ONCE FOR EACH BYTE OR BY LEAVING THE GATE GATE LINES ACTIVE AND USING "READ CLOCK" AND "WRITE CLOCK" LINES TO TIME THE TRANSFER OF INDIVIDUAL BYTES.

9. IF A DEVICE CAN SUPPORT SIMULTANEOUS READING AND WRITING, THE CONTROLLER CAN ASSERT BOTH "READ GATE" AND "WRITE GATE" SIMULTANEOUSLY WITHOUT CAUSING AN ERROR. NORMAL TRANSFER TIMING PROTOCOLS FOR EACH DIRECTION ARE STILL USED. THE DATA TRANSFER CAN BE EITHER SERIAL OR PARALLEL.

10. THE SPECIFICATION ALLOWS DEVICES OTHER THAN A DISK DRIVES TO BE USED WITH SADI. IN THAT CASE THE DRIVE DEPENDENT FUNCTION LINES MAY BE REDEFINED. "SEEK COMPLETE", "INDEX" AND "SECTOR" CAN THEN BE INTERPRETTED AS ADDITIONAL "STATUS x" BITS. THE "SEEK START", "RECAL" AND "OFF LINE SEEK" COMMANDS CAN THEN BE INTERPRETTED AS ADDITIONAL "COMMAND x" BITS. 'MODE 2', 'MODE 3', 'MODE 4' AND 'MODE 5' CAN THEN ALSO BE INTERPRETTED AS DEVICE DEPENDENT FUNCTIONS. ALL FAULT CODES EXCEPT 0 (NO FAULT) CAN BE REDEFINED. NORMAL SERIAL OR PARALLEL DATA TRANSFER CAN BE USED AS APPROPRIATE. OF COURSE, A CONTROLLER CAPABLE OF HANDLING THE DEVICE MUST BE USED.

11. THERE IS NO REQUIREMENT THAT ONLY ONE DRIVE OR DEVICE TYPE BE ON A SADI STRING AT A TIME. SINCE THE "DEVICE ID" CODES ARE UNIQUE TO EACH DEVICE TYPE, A VERY SMART CONTROLLER CAN USE THE CODE TO TELL IT HOW TO HANDLE EACH DEVICE.

END