

S16A

SBus 16-bit Dual Analog Interface
for the Sun SPARCstation

USER'S GUIDE

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Overview

The S16A SBus 16-bit Dual Analog Interface is a single-slot board for SBus-based computer systems. The S16A has two analog I/O channels, each incorporating one 16-bit Analog-to-Digital (ADC) converter and one 20-bit Digital-to-Analog (DAC) converter. The S16A is designed for continuous input and output on both channels simultaneously and is typically used for scientific and medical research and development.

The S16A employs two Burr-Brown[®] PCM1702 analog output DACs running at a sample rate of 705.6KHz, which is 16 times the standard audio frequency of 44.1 KHz.

The two S16A analog input ADCs are National Semiconductor[®] ADC16071s, running with a base sampling rate of 192KHz. The S16A provides a clock prescale register to divide this frequency down for lower rates.

The S16A uses the SBus DMA interface and can transmit or receive any amount of data to and from host memory continuously on both channels at once.

Each I/O channel's input ADC can monitor a differential signal, either of the two differential inputs as a single-ended signal, either of two I/O channels' DAC outputs, or a reference ground. The ability to monitor the outputs directly or ground allows the S16A to be tested and adjusted using these internal loop-backs.

A portion of the functionality of the S16A is contained in a sub-assembly, the Analog Input Module. This module is controlled and configured using a byte-sequence protocol, as described in the section **Analog Input Module Control Protocol** beginning on page 34.

The S16A boards fully support the requirements of the SunOS operating system. Example programs are included. Each of the two I/O channels appears as two subdevices to the SunOS operating system, one for input and one for output, for a total of four subdevices.

This document explains how to install the S16A interface and driver and how to write applications for it. It is divided into the following sections:

Installation	describes how to install the board and its related software.
Input and Output	describes the programming interface library.
Hardware Interface Protocol	provides a connector pin-out diagram and describes the S16A signals and timing.
Registers	describes the hardware registers.
Specifications	lists the product specifications.
References	lists other documentation resources that may be helpful.
Contacting EDT	describes how to contact EDT, and how to access EDT resources on the Internet.

Installation

Installing the S16A SBus 16-bit Dual Analog Interface is a two-step process. First you must physically install the board inside the host computer. Then you must install the software driver so that applications can access the S16A. Hardware installation is described in the following section. Software installation is described in the section after.

Installing the Hardware

The S16A board is a single-slot SBus board. To install it, refer to your SBus host computer documentation for complete information on installing an SBus board. For example, many Sun systems contain this information in a manual entitled *SPARCstation Installation Guide*.

Use the following procedure to install the SBus 16-bit Dual Analog Interface:

CAUTION

Both the S16A and your SBus host computer contain static-sensitive components. Install the S16A at a static-free work area. If a static-free work area is not available, take the following precautions to reduce the risk of component damage:

1. Remove from the immediate area all materials that can generate or hold a static charge.
 2. Discharge yourself by touching both hands to a metal portion of the host computer's chassis before you open the host computer or open the S16A static-shielded bag.
-
-

1. Unpack the SBus 16-bit Dual Analog Interface from the shipping packaging. Do not remove the S16A from the static shielding bag until you remove all other packaging materials from the area and establish a static-free work area.
2. Install the S16A in the SBus host, following the directions provided with the SBus host. The S16A can be installed in any DMA slot.

To remove the SBus 16-bit Dual Analog Interface, reverse the installation procedure.

The SBus 16-bit Dual Analog Interface connects to your device with a cable. This cable is typically device-specific.

Installing the Software

The S16A can run on a Sun workstation using either SunOS Version 4.1.3 or later or Solaris 2.4 or later (System V Release 4, or SVR 4). The installation procedures differ. Both are given below.

Using SunOS Version 4.1

If you are using SunOS Version 4.1.3 or later, use the following procedure to install the S16A driver:

1. Become root or superuser.
2. Create a directory in which you wish to install the S16A driver. EDT suggests `/var/EDTs16a`.
3. Change to the directory in which you wish to install the S16A driver.

4. Place the diskette that came with the S16A into the diskette drive.
5. The S16A driver and related files are included on a diskette in *tar* format. To copy them to your hard disk, enter:

```
tar xvf /dev/rfd0
```

6. The *tar* program extracts a number of files. (The list of files distributed is provided in the section entitled **Included Files**.) The S16A diskette contains versions of the S16A driver for a variety of Sun platforms and versions of the Sun operating system. The installation program installs the correct driver based on the host platform and operating system version.

7. To install the driver, enter:

```
make install
```

The makefile provided installs and loads the S16A driver.

8. During the installation, the following question appears on the display:

```
Automatically load the S16A driver during each reboot? [y|n] (y):
```

Entering *y* (or simply typing <Return>) causes the S16A driver to be loaded whenever you reboot your host computer. If you respond with *n*, you must manually reload the driver after rebooting. To do so, enter:

```
make load
```

9. During the installation, the following question appears on the display:

```
How many S16A devices do you want? (1):
```

You can install as many S16A boards in your system as you have DMA SBus slots available. Enter the number corresponding to the number of S16A boards you have installed in your system. If you simply type <Return>, one S16A device entry is installed. Note that each S16A board is appears to SunOS as one main device and four unidirectional subdevices, one input and one output each for both of the analog I/O channels.

NOTE: If you anticipate installing more than one S16A board into your system, install as many S16A device entries as you will ultimately require. The extra device entries will do no harm and will be there when you need them, saving you a step.

10. If the S16A has not been installed inside the host computer, or has been installed incorrectly, the following message appears on the display:

```
Can't load this module
```

If you see this message, go back to the section entitled **Installing the Hardware** and reinstall the board. If troubles persist, contact EDT for further assistance.

To unload the S16A driver:

1. Change to the directory in which you placed the S16A files, if you are not already there.
2. Become root or superuser.

3. Enter:

```
make unload
```

Using System V Release 4 (Solaris 2.4 or Later)

If you are using Sun System V Release 4 (Solaris 2.4 or later), use the following procedure to install the S16A driver:

1. Become root or superuser.
2. Place the diskette that came with the S16A into the diskette drive.
3. Enter:

```
volcheck  
pkgadd -d /floppy/floppy0 EDTs16a
```

The *pkgadd* program asks several confirmation questions, which you can answer with a *y* for affirmative. Refer to your Solaris system administration documentation for further information on the *pkgadd* command.

To remove the S16A driver:

1. Become root or superuser.
2. Enter:

```
pkgrm EDTs16a
```

For further details, consult your Solaris 2.0 documentation, or call Engineering Design Team, Inc.

Building the Sample Programs

To build any of the example programs, enter the command:

```
make file
```

where *file* is the name of the example program you wish to install, without the *.c* suffix.

To build and install all the example programs, simply enter the command:

```
make
```

All example programs display a message that explains their usage when you invoke them with the *-h* switch.

Included Files

The S16A driver release diskette contains the following files (see the *readme* file for a complete, up-to-date listing):

s16a.o.sun4c	The executable S16A driver for SunOS 4.1.3 on a Sun 4C architecture such as a SPARCStation 1, 1+, 2, or IPC.
s16a.o.sun4m	The executable S16A driver for SunOS 4.1.3 on a Sun 4M architecture such as a SPARCStation 5, 10, 20, LX, Classic, or an Ultra 1 or 2.
s16a	The executable S16A driver for Solaris Version 2.4 or later.
s16aload.c	Initializes the S16A Xilinx hardware at boot time.
s16a.rbt	Xilinx data file.
drv_ioctl.h	Common driver architecture <i>ioctl</i> definitions.
s16a_reg.h	Hardware definitions for the drivers.
libs16a.h	Library definitions for applications using the libs16a.a library.
libs16a.c	Source code for the libs16a.a library.
s16a.h	The S16A driver header file, defining <i>ioctls</i> and registers.
s16a.INSTALL	The installation script used by the S16A makefile.
makefile	The makefile for installing, loading, and unloading the S16A driver, and making example programs. Used with the SunOS <i>make</i> command to automatically install the driver or compile the example programs.
README	An ASCII file containing last-minute information about the S16A software.
setdebug.c	This file sets the internal driver debug levels for the S16A. Call EDT for details.
calfiles/*	Calibration files whose names match the serial numbers of shipped units.

Input and Output

The driver can perform two kinds of DMA transfers: continuous and noncontinuous. For noncontinuous transfers, the driver uses DMA system calls for *read()* and *write()*. Each *read()* and *write()* system call allocates kernel resources, during which time DMA transfers are interrupted.

To perform continuous transfers, use the ring buffers. The ring buffers area set of buffers that applications can access continuously, reading and writing as required. When the last buffer in the set has been accessed, the application then cycles back to the first buffer. See **s16a_configure_ring_buffers** for a complete description of the ring buffer parameters that you can configure.

Elements of S16A Applications

S16A applications for performing noncontinuous transfers typically include the following elements:

1. The preprocessor statement

```
#include "libs16a.h"
```

2. A call to *s16a_open()*, such as:

```
s16a_p = s16a_open(s16a_p) ;
```

3. A call to *s16a_read()* or *s16a_write()*, such as:

```
s16a_read(s16a_p, buf_ptr, 512) ;
```

or:

```
s16a_write(s16a_p, buf_ptr, 1024) ;
```

4. A call to *s16a_close()* to close the device before ending the program, such as:

```
s16a_close(s16a_p) ;
```

5. The *-ls16a* option to the compiler, to link the library file *libs16a.a* with your program

S16A applications for performing continuous transfers typically include the following elements:

1. The preprocessor statement

```
#include "s16a.h"
```

2. A call to *s16a_open()*, such as:

```
s16a_p = s16a_open(s16a_p) ;
```

3. A call to *s16a_configure_ring_buffers()* to set up the ring buffers as required, such as:

```
s16a_configure_ring_buffers(s16a_p, 1024, 4, NULL, EDT_READ) ;
```

4. A call to *s16a_start_buffers()* with an argument of 0 to initiate a continuous transfer, such as:

```
s16a_start_buffers(s16a_p, 0) ;
```

5. A call to *s16a_wait_for_buffer()* or *s16a_wait_for_next_buffer()* to , such as:

```
buf_ptr = s16a_wait_for_buffer(s16a_p, 4) ;
```

6. A call to *s16a_close()* to close the device before ending the program, as in:

```
s16a_close(s16a_p) ;
```

7. The `-ls16a` option to the compiler, to link the library file `libs16a.a` with your program

See the makefile and example programs provided for examples of compiling code using the library routines.

DMA Library Routines

The DMA library provides a set of consistent routines across many of the EDT products, with simple yet powerful ring-buffered DMA capabilities. **Table 1, DMA Library Routines** lists the general DMA library routines. In addition, if driver-specific library routines exist, they can be found in a table thereafter.

The sections that follow describe the DMA library routines in alphabetical order.

Routine	Description
<code>s16a_open</code>	Opens the S16A for application access.
<code>s16a_close</code>	Terminates access to the S16A and releases resources.
<code>s16a_read</code>	Single, application-level buffer read from the S16A.
<code>s16a_write</code>	Single, application-level buffer write to the S16A.
<code>s16a_set_defaults</code>	Restores the driver and hardware to factory-specified default state.
<code>s16a_configure_ring_buffers</code>	Configures the ring buffers.
<code>s16a_buffer_addresses</code>	Returns addresses of ring buffers.
<code>s16a_wait_for_buffer</code>	Blocks until specified buffers have completed.
<code>s16a_wait_for_next_buffer</code>	Blocks until the next buffer completes.
<code>s16a_check_next_buffer</code>	Checks whether next buffer is complete.
<code>s16a_start_buffers</code>	Begins transfer from or to specified number of buffers.
<code>s16a_cancel</code>	Shuts down the device as soon as possible, optionally resets it.
<code>s16a_cancel_current</code>	Cancels the current DMA, moves pointers to the next.
<code>s16a_stop_buffers</code>	Stops the interface after all buffers have completed.
<code>s16a_done_count</code>	Return absolute (cumulative) number of completed buffers.
<code>foi_parity_error</code>	Checks for parity error since last call.

Table 1. General DMA Library Routines

The following driver-specific routines are also available:

Routine	Description
s16a_get_dac_control_reg	Get the current state of the output DAC control register.
s16a_get_dio_data_reg	Get the current state of the DIO Data register.
s16a_get_dio_direction_reg	Get the current state of the DIO Direction register.
s16a_get_output_bits	Get the output resolution of the S16A.
s16a_serial_read	Read a response string from the Analog Input module.
s16a_serial_str	Send a command string to the Analog Input module and return the response only if it differs from the string sent.
s16a_serial_write	Send a command string to the Analog Input module.
s16a_set_dac_control_reg	Write a value to the output DAC Control register.
s16a_set_dio_data_reg	Write a value to the DIO Data register.
s16a_set_dio_direction_reg	Write a value to the DIO Direction register.
s16a_set_output_bits	Set the output resolution of the S16A.

Table 2. S16A-specific Library Routines

s16a_buffer_addresses

Description

Returns an array containing the addresses of the buffers.

Syntax

```
void **s16a_buffers(S16aDev *s16a_p);
```

Arguments

s16a_p S16A device handle returned from *s16a_open*.

Return

Address of an array of pointers to the ring buffers allocated by the driver or the library. The array of buffer pointers is allocated by the library. Null on error.

s16a_cancel

Description

Stops any transfers currently in progress, resets the ring buffer pointers to restart on the current buffer.

Syntax

```
int s16a_cancel(S16aDev *s16a_p);
```

Arguments

s16a_p S16A device handle returned from *s16a_open*.

Return

0 on success, -1 on failure. Sets *errno* on failure.

s16a_cancel_current

Description

Stops the current transfers, resets the ring buffer pointers to the next buffer.

Syntax

```
int s16a_cancel(S16aDev *s16a_p);
```

Arguments

s16a_p S16A device handle returned from *s16a_open*.

Return

0 on success, -1 on failure. Sets *errno* on failure.

s16a_check_next_buffer

Description

Checks whether the next buffer is complete.

Syntax

```
int s16a_check_next_buffer(S16aDev *s16a_p);
```

Arguments

s16a_p S16A device handle returned from *s16a_open*.

Return

0 on success, -1 on failure. Sets *errno* on failure.

s16a_close

Description

Closes the device associated with the device handle and frees the handle.

Syntax

```
int s16a_close(S16aDev *s16a_p);
```

Arguments

s16a_p S16A device handle returned from *s16a_open*.

Return

0 on success, -1 on failure. Sets *errno* on failure.

s16a_configure_ring_buffers

Description

Configures the SBus 16-bit Dual Analog Interface ring buffers. Any previous configuration is replaced, and previously allocated buffers are released.

Buffers can be allocated and maintained within the SBus 16-bit Dual Analog Interface library or within the user application itself.

Syntax

```
int s16a_configure_ring_buffers(S16aDev *s16a_p, int bufsize, int nbufs,
                               void *bufarray[], int data_output);
```

Arguments

<i>s16a_p</i>	S16A device handle returned from <i>s16a_open</i>
<i>bufsize</i>	size of each buffer. For optimal efficiency, allocate a value approximating throughput divided by 20: that is, if transfer occurs at 20 MB per second, allocate 1 MB per buffer. Buffers significantly larger or smaller can overuse memory or lock the system up in processing interrupts.
<i>nbufs</i>	number of buffers. Must be 1 or greater. Four is recommended.
<i>bufarray</i>	array of pointers to individual buffers if the buffers are allocated by the application. Must be NULL if in library, or have <i>nbufs</i> elements.
<i>library</i>	Must be NULL.
<i>user</i>	This array must be filled with the addresses of the buffers allocated by the application for the library to use.
<i>data_direction</i>	Indicates whether this connection is to be used for input or output. Only one direction is possible per device or subdevice: EDT_READ = 0 EDT_WRITE = 1

Return

0 on success; -1 on error. If all buffers cannot be allocated, none are allocated and an error is returned.

s16a_done

Description

Returns the cumulative count of completed buffer transfers.

Syntax

```
int s16a_done_count(S16aDev *s16a_p);
```

Arguments

s16a_p S16A device handle returned from *s16a_open*.

Return

The number of completed buffer transfers. Completed buffers are numbered consecutively starting with 0 when the S16A is opened. (Thus, the allocated buffer number is the transferred buffer number modulo the number of allocated buffers.)

s16a_get_dac_control_reg

Description

Get current state of the output DAC control register. To check for an error, clear the *errno* global variable before calling this function, then check it for non-zero after the function returns.

Syntax

```
u_int s16a_get_dac_control_reg(S16aDev *s16a_p);
```

Arguments

s16a_p S16A device handle returned from *s16a_open*

Return

Integer containing current state of the DAC Control register. The global variable *errno* is set on error.

s16a_get_dio_data_reg

Description

Get current state of the DIO Data register. The low 12 bits reflect the current state of the DIO pins. Bits that are configured as outputs are read as zero. To check for an error, clear the *errno* global variable before calling this function, then check it for nonzero after the function returns.

Syntax

```
u_int s16a_get_dio_data_reg(S16aDev *s16a_p);
```

Arguments

s16a_p S16A device handle returned from *s16a_open*

Return

Integer containing current state of the DIO Data register. The global variable *errno* is set on error.

s16a_get_dio_direction_reg

Description

Get current state of the DIO Direction register. The low 12 bits reflect the configuration of the corresponding DIO pins. If a bit is set, the DIO pin of the same number is configured as an output signal. To check for an error, clear the *errno* global variable before calling this function, then check it for nonzero after the function returns.

Syntax

```
u_int s16a_get_dio_direction_reg(S16aDev *s16a_p);
```

Arguments

s16a_p S16A device handle returned from *s16a_open*

Return

Integer containing current state of the DIO Direction register. The global variable *errno* is set on error.

s16a_get_output_bits

Description

Get the output resolution of the S16A. Returns 16 or 20, reflecting the current driver setting for the output channel.

Syntax

```
int s16a_get_output_bits(S16aDev *s16a_p);
```

Arguments

s16a_p S16A device handle returned from *s16a_open*

Return

Returns 16 or 20 on success; returns -1 if the *ioctl* driver call fails, and sets *errno* to indicate the problem.

s16a_open

Description

Opens the specified S16A and sets up the device handle.

Syntax

```
S16aDev *s16a_open(int unit, int channel, int output);
```

Arguments

unit specifies the device unit number

channel specifies the analog I/O channel number: 0 or 1

output specifies the direction: 1 means the output subdevice; 0 means the input subdevice

Return

A handle of type (S16aDev *), or NULL if error. If an error occurs, check the *errno* global variable for the error number.

s16a_read

Description

Performs a read on the S16A. The UNIX 2 GB file offset bug is avoided during large amounts of input or output, that is, reading past 2^{31} does not fail. This call is not multibuffering, and no transfer is active when it completes.

Syntax

```
int s16a_read(S16aDev *s16a_p, void *buf, int size);
```

Arguments

<i>s16a_p</i>	S16A device handle returned from <i>s16a_open</i>
<i>buf</i>	address of buffer to read into
<i>size</i>	size of read in bytes

Return

The return value from *read*; *errno* is set by *read* on error.

s16a_serial_read

Description

Read a response string from the Analog Input Module.

Syntax

```
int s16a_serial_read(S16aDev *s16a_p, char *buf, size);
```

Arguments

<i>s16a_p</i>	S16A device struct, returned from <i>s16a_open</i>
<i>buf</i>	Array of characters to receive the response string from the Analog Input Module
<i>size</i>	Number of characters in the buffer

Return

Returns the actual number of bytes transferred; or -1 on *ioctl* error. Sets *errno* on failure.

s16a_serial_str

Description

Send a command string to the Analog Input Module. Read the response from the AIM and return it only if it differs from the command string sent. Otherwise return NULL. This routine is especially useful for command strings, which echo the command string, unless an error occurs.

Syntax

```
char *s16a_serial_str(S16aDev *s16a_p, char *str);
```

Arguments

s16a_p S16A device struct, returned from *s16a_open*
str Null-terminated command string to send to the Analog Input Module

Return

NULL indicates a response string that matches the input command string, which indicates successful transmission. Otherwise, this routine returns a pointer to a string containing the characters received in response to the command string. The response string is in a single buffer allocated by the library. Therefore, if you need to preserve the response string, you must copy it to another buffer before making another `libs16a.a` library call. Sets *errno* on failure.

s16a_serial_write

Description

Send a command string to the Analog Input Module.

Syntax

```
int s16a_serial_write(S16aDev *s16a_p, char *buf, size);
```

Arguments

s16a_p S16A device struct, returned from *s16a_open*
buf Array of characters containing the command string to send to the Analog Input Module
size Number of characters in the command string

Return

Success: number of characters transferred; -1 on driver error. Sets *errno* on failure.

s16a_set_dac_control_reg

Description

Write a specified value to the output DAC Control register.

Syntax

```
int s16a_set_dac_control_reg(S16aDev *s16a_p, int value);
```

Arguments

s16a_p S16A device handle returned from *s16a_open*
value Value to write to the DAC Control register.

Return

Returns 0 on success or -1 on failure. Fails if *s16a_p* does not refer to an output channel. Sets *errno* on failure.

s16a_set_defaults

Description

Resets the S16A configuration to its default state:

- The Xilinx Programming registers are set to S16A_XRESET and then cleared.
- The UART Command/Status register and the DAC Output Control register are set to 0.
- Gain and offset values are set from */dev/s16a.cfg*, which is generated when you run *s16acalibrate*.
- Ring buffer mode is disabled and driver- or library-allocated ring buffers are released.

Syntax

```
int s16a_set_defaults(S16aDev *s16a_p);
```

Arguments

s16a_p S16A device handle returned from *s16a_open*

Return

Return value from *ioctl* call to driver: 0 on success; -1 on error. If an error occurs, check the *errno* global variable for the error number.

s16a_set_dio_data_reg

Description

Write a specified value to the DIO Data register. Only the low 12 bits are significant; of these, bits that are configured as inputs are ignored when written.

Syntax

```
int s16a_set_dio_data_reg(S16aDev *s16a_p, int value);
```

Arguments

s16a_p S16A device handle returned from *s16a_open*
value Value to write to the DIO Data register.

Return

Returns 0 on success or -1 on failure. Fails if *s16a_p* does not refer to an output channel. Sets *errno* on failure.

s16a_set_dio_direction_reg

Description

Write a specified value to the DIO Direction register. The low 12 bits configure the corresponding DIO pins. If a bit is set, the DIO pin of the same number is configured as an output signal.

Syntax

```
int s16a_set_dio_direction_reg(S16aDev *s16a_p, int value);
```

Arguments

s16a_p S16A device handle returned from *s16a_open*
value Value to write to the DIO Direction register.

Return

Returns 0 on success or -1 on failure. Fails if *s16a_p* does not refer to an output channel. Sets *errno* on failure.

s16a_set_output_bits

Description

Set the output resolution of the S16A to 16 or 20 bits.

Syntax

```
int s16a_set_output_bits(S16aDev *s16a_p, int value);
```

Arguments

s16a_p S16A device handle returned from *s16a_open*
value Either 16 or 20, indicating the operational mode of the output DAC.

Return

Returns 0 on success or -1 on failure. Fails if *s16a_p* does not refer to an output channel, or if *value* is anything but 16 or 20. Sets *errno* on failure.

s16a_start_buffers

Description

Releases the specified number of buffers to the driver for transfer.

Syntax

```
int s16a_start_buffers(S16aDev *s16a_p, int bufnum);
```

Arguments

s16a_p S16A device handle returned from *s16a_open*
bufnum Number of buffers to release to the driver for transfer. An argument of 0 causes the driver to perform continuous transfers.

Return

0 on success; -1 on error. If an error occurs, check the *errno* global variable for the error number.

s16a_stop_buffers

Description

Stops DMA transfer after the current buffer has completed, whether DMA is occurring continuously or noncontinuously. If DMA is continuous, also dismantles ring buffer mode and frees the resources it consumed.

Syntax

```
int s16a_stop_buffers(S16aDev *s16a_p);
```

Arguments

s16a_p S16A device handle returned from *s16a_open*

Return

0 on success; -1 on error. If an error occurs, check the *errno* global variable for the error number.

s16a_wait_for_buffer

Description

Blocks until the specified buffer is returned from the driver.

Syntax

```
void *s16a_wait_buffers(S16aDev *s16a_p, int bufnum);
```

Arguments

s16a_p S16A device handle returned from *s16a_open*

bufnum buffer number for which to block. Completed buffers are numbered cumulatively starting with 0 when the S16A is opened. (Thus, the allocated buffer number is the transferred buffer number modulo the number of allocated buffers.)

NOTE: If you wait for all the buffers, the driver is left with none to use when this call returns, and an overrun or underrun will occur.

Return

Address of last completed buffer on success; NULL on error. If an error occurs, check the *errno* global variable for more information.

s16a_wait_for_next_buffer

Description

Blocks until the next buffer is returned from the driver. Returns immediately if a buffer is already complete. The completed buffers are numbered consecutively, so the first call to *s16a_wait_for_next_buffer* returns the address of buffer 0, the next will be 1, and so on.

Syntax

```
void *s16a_wait_next_buffer(S16aDev *s16a_p);
```

Arguments

s16a_p S16A device handle returned from *s16a_open*

Return

Address of completed buffer on success; NULL on error. If an error occurs, check the *errno* global variable for more information.

s16a_write

Description

Perform a write on the S16A. The UNIX 2 GB file offset bug is avoided during large amounts of input or output; that is, writing past 2^{31} does not fail. This call is not multibuffering, and no transfer is active when it completes.

Syntax

```
int s16a_write(S16aDev *s16a_p, void *buf, int size);
```

Arguments

s16a_p S16A device handle returned from *s16a_open*

buf address of buffer to write from

size size of write in bytes

Return

The return value from *write*; *errno* is set by *write* on error.

foi_parity_error

Description

Checks to determine if a parity error has occurred since the last time this routine was called and returns 0 if not, 1 if so, and -1 if the routine is not supported for a particular device or an illegal argument was provided.

Syntax

```
int foi_parity_error(S16aDev *s16a_p);
```

Arguments

s16a_p S16A device handle returned from *s16a_open*

Return

0 if no error; 1 if parity error; -1 if the routine is not supported or if an illegal argument was provided.

Error Conditions

The table below shows some of the error codes that may be received from a call to the S16A driver. After any I/O system call, the *errno* global variable contains the error code, if any, and the *perror* system call can print out a string describing the error code. Refer to your system programming documentation for details about *errno* and *perror*.

Error Code	Failing Driver Call	Error Condition
ENXIO	<i>open</i>	The S16A attach failed. The device is not present.
EEXIST	<i>open</i>	The S16A is already opened with an exclusive lock.

Table 3. Error Codes and Conditions

Hardware Interface

This section describes how to connect your device to an S16A interface, including the electrical characteristics of the signal, the signal descriptions, the timing specifications, and the connector pinout.

Electrical Interface

The two S16A analog inputs each have the following characteristics:

- 100 KOhm impedance
- configurable input sources:
 - differential input signals
 - either of the two differential leads (“plus” and “minus”) as a single-ended signal
 - either of the analog outputs
 - ground
- base input range: -2.5 to +2.5 volts
- input gain adjustments ranging from 1 to 100 power, in 7 steps
- offset and gain trim adjustments

The S16A analog outputs have the following characteristics:

- low impedance (70 Ohm)
- single-ended (non-differential) signals
- 20-bit precision
- range from -2.5 to +2.5 volts
- separate adjustable level offsets.

The S16A also provides 12 general-purpose I/O pins, each of which can be configured as either input or output. The outputs are TTL-level, high-impedance (1 KOhm); the inputs are TTL-level (0–5 volt) compatible.

Interface Signals

The following table describes the signals in the external connector.

Signal	S16A I/O	Description
DIO00-11	I/O	Configurable I/O pins.
CH0OUT	O	Output of channel 0.
CH1OUT	O	Output of channel 1.
CH0INP	I	Channel 0 "plus" input. Configurable as one of a pair of differential signals, the only single-ended signal, or disabled.
CH0INM	I	Channel 0 "minus" input. Configurable as one of a pair of differential signals, the only single-ended signal, or disabled.
CH1INP	I	Channel 1 "plus" input. Configurable as one of a pair of differential signals, the only single-ended signal, or disabled.
CH1INM	I	Channel 1 "minus" input. Configurable as one of a pair of differential signals, the only single-ended signal, or disabled.
UVCC	O	Available +5 volt supply. Thermally fused for 200 mA, resets after cooling.

Table 4. S16A Interface Signals

Connector Pinout

The S16A uses a 37-pin D connector, such as an AMP 748878-1.

The following pinout diagram describes the connection from the S16A board to the cable.

NOTE: Do not connect your own circuits to the unused pins, as they may be internally connected to the S16A.

Pin	Signal	Pin	Signal
1	DIO00	20	DIO01
2	DIO02	21	DIO03
3	Ground	22	Ground
4	DIO04	23	DIO05
5	DIO06	24	DIO07
6	Ground	25	Ground
7	DIO08	26	DIO09
8	DIO10	27	DIO11
9	Ground	28	Ground
10	CH0OUT	29	Ground
11	Ground	30	CH0INP
12	CH0INM	31	Ground
13	Ground	32	Reserved
14	Reserved	33	Ground
15	Ground	34	CH1INP
16	CH1INM	35	Ground
17	Ground	36	CH1OUT
18	Ground	37	Ground
19	UVCC		

Table 5. Connector Pinout

Registers

The S16A SBus 16-bit Dual Analog Interface is configured and controlled with 8-bit and 32-bit SBus registers. Eleven additional internal registers in the Analog Input Module are accessed indirectly through the SBus registers using a simple protocol. Applications access S16A registers through library calls or *ioctl* calls with S16A-specific parameters, as described in the `s16a.h` header file.

***NOTE:* All registers initialized and manipulated by the S16A driver. User applications do not ordinarily need to read or write these registers.**

In addition, the S16A provides a standard SBus configuration ROM at the beginning of its block of addresses. Thus the S16A answers with valid data for the first 64 KBytes, in addition to the SBus registers.

SBus Addresses

The addresses listed in the figure below are offsets from the SBus slot base address. Obtain the SBus base address from the SBus host documentation. The following sections describe the S16A registers in detail.

0x0006.0000	reserved	
...	not used	
0x0004.00C4	uart_data	
0x0004.00C0	uart_csr	
...	not used	
0x0004.0080	dac_ctrl	
...	not used	
0x0004.0044	dio_data	
0x0004.0040	dio_dir	
0x0004.003C	nxt_cnt_ctl_3	
0x0004.0038	cur_cnt_3	
0x0004.0034	nxt_dma_add_3	
0x0004.0030	cur_dma_add_3	
...	...	
0x0004.000C	nxt_cnt_ctl_0	
0x0004.0008	cur_cnt_0	
0x0004.0004	nxt_dma_add_0	
0x0004.0000	cur_dma_add_0	
...	not used	
0x0002.0008	xpg_stat	not used
0x0002.0004	xpg_din	not used
0x0002.0000	xpg_reg	not used
...	not used	
0x0000.FFFC	S16A ROM	
0x0000.0000		

Byte	0	1	2	3
Word	0		1	

Figure 1. S16A SBus Addresses

DMA Registers

The S16A provides four independent DMA channels: one each for input and output for each of the two analog I/O channels. Each DMA channel can be accessed to set up a new DMA transfer while it is currently performing a DMA transfer. When the current transfer completes the new one begins automatically without pause, allowing non-stop I/O on both I/O channels in both directions.

The following table shows the assignment of DMA channels to I/O channels.

DMA Channel	Use
0	Analog I/O channel 0 Input
1	Analog I/O channel 1 Input
2	Analog I/O channel 0 Output
3	Analog I/O channel 1 Output

Table 6. DMA Channel Assignments

Current DMA Address Registers

The Current DMA Address registers are 32-bit read-only registers at addresses 0x40000, 0x40010, 0x40020, and 0x40030, one for each DMA channel. The second-lowest hexadecimal address digit specifies the DMA channel.

These registers hold the address of the DMA currently in progress for each channel. When the current DMA transfer on a channel completes, if there is a "next" one set up, the contents of the Next DMA Address register for the channel are copied to the Current DMA Address register, the next count is copied to the Current DMA Count register, and the new transfer is started automatically.

Bit	Description
31–20	The 1 MB page addressed by the DMA.
19–2	When read, the next address to access on the SBus.
1–0	Always 0. S16A DMA transfers must be 32-bit word-aligned.

Table 7. Current DMA Address Registers

Next DMA Address Registers

The Next DMA Address registers are 32-bit registers at addresses 0x40004, 0x40014, 0x40024, and 0x40034, one for each DMA channel. The second-lowest hexadecimal address digit specifies the DMA channel.

These registers hold the address of the next DMA transfer to be performed for each channel. When the current DMA transfer on a channel completes, if there is a “next” one set up, the contents of the Next DMA Address register for the channel are copied to the Current DMA Address register, the next count is copied to the Current DMA Count register, and the new transfer is started automatically.

Bit	Description
31–20	Show or store the 1 MB page addressed by the next DMA.
19–2	Show or store the address within the page for next DMA to use.
1–0	Set to 0. S16A DMA transfers must be 32-bit word-aligned.

Table 8. Next DMA Address Registers

Current Count Registers

The Current Count registers are 32-bit read-only registers at address 0x40008, 0x40018, 0x40028, and 0x40038, one for each channel. The second-lowest hexadecimal address digit specifies the DMA channel. The maximum byte count for a single DMA transfer is 1 MB. Each of these registers reflects the counter for the current DMA transfer in progress (if any) on it's channel.

Bit	Description
31–20	Always 0.
19–2	When read, these bits display how many words remain in the DMA transfer currently in progress.
1–0	Always 0. S16A DMA transfers consist of whole 32-bit words.

Table 9. Current Count Registers

Control and Next Count Registers

The Control And Next Count registers are 32-bit registers at address 0x4000C, 0x4001C, 0x4002C, and 0x4003C. The second-lowest hexadecimal address digit specifies the DMA channel. These registers provide the transfer counts and control of the DMA hardware for each of the four DMA channels.

Bit	S16A_	Description
31	INT	A read-only status bit. A value of 1 indicates the S16A is asserting an SBus interrupt.
30		Unused. 0 when read.
29	DMA_START	A value of 1 enables DMA transfer.
28		Unused. 0 when read.
27	EN_EODMA	A value of 1 enables end-of-DMA interrupt.
26		Unused. 0 when read.
25	DMA_DIR_READ	DMA direction: a value of 1 reads host memory, 0 writes it. For channels 0 & 1 must be 0; for channels 2 & 3 must be 1.

Table 10. Control and Next Count Registers

Bit	S16A_	Description
24	BURST_EN	A value of 1 enables burst transfer. For channels 0 & 1 must be 0; for channels 2 & 3 must be 1.
23–20		Unused. 0 when read.
19–2	SIZ_MSK	Number of words to transfer in the next DMA transfer. When the next DMA starts, this value is copied into the corresponding bits of the current count register.
1–0	CNT_MSK	Always 0. S16A DMA transfers consist of whole 32-bit words.

Table 10. Control and Next Count Registers (Continued)

Direct I/O Registers

The S16A provides 12 pins in its external connector that can be used for general-purpose I/O signals. Each pin can be configured as either an input signal or an output signal. Signal levels are TTL-level (0 or +5 volt) with 1 KOhm source impedance. The following sections describe how to access these signals.

DIO Direction Register

The DIO Direction register is a 32-bit register at address 0x40040. This register configures the 12 DIO pins in the S16A connector to be either input or output. Each of the low 12 bits in this register controls the corresponding DIO signal: if the bit is set, the pin is an output signal; if the bit is clear, the pin is an input signal.

DIO Data Register

The DIO Data register is a 32-bit register at address 0x40044. The low 12 bits in this register reflect the state of the corresponding DIO pins in the S16A connector. Writes to this register set the states of the pins that have been configured to be output signals; reads return the states of the pins that have been configured to be input signals.

DAC Output Control Register

The DAC Output Control register is a 32-bit register at address 0x40080. This register controls the output analog converters. Each of the two channels' output converters can be enabled or disabled, and can be configured for 16-bit or 20-bit DAC operation. In 16-bit mode, each sample uses two bytes of DMA data; in 20-bit mode, each sample uses four bytes of DMA data.

Upon the first open of an I/O channel for output, the driver enables the channel and configures it for 20-bit operation. The operational mode can then be changed by a library or ioctl call after the channel is opened. When the channel is closed, the driver clears the enable bit, disabling the output.

Bit	S16A_	Description
0	OUT0_ENABLE	Enables I/O channel 0 output
1	OUT0_20BIT	When set, configures I/O channel 0 as 20-bit digital-to-analog; when clear, the channel is in 16-bit mode.
4	OUT1_ENABLE	Enables I/O channel 1 output
5	OUT1_20BIT	When set, configures I/O channel 1 as 20-bit digital-to-analog; when clear, the channel is in 16-bit mode.

Table 11. DAC Output Control Register

Analog Input Module Internal Registers

The Analog Input Module contains 11 internal registers, described in the following sections, that control the analog input and other settings. These registers are accessed using the two UART registers described in the section **Analog Input Module UART Registers** beginning on page 34.

Name	Description
Input Clock Prescale 0 In	Provides a divisor from the base 192 KHz clock for input channel 0.
Input Clock Prescale 1 In	Provides a divisor from the base 192 KHz clock for input channel 1.
Input Configuration 0 In	Controls the input source and the gain for input channel 0.
Input Configuration 1 In	Controls the input source and the gain for input channel 1.
Trim Output Offset 0	Controls the output voltage offset adjustment for output channel 0.
Trim Output Offset 1	Controls the output voltage offset adjustment for output channel 1.
Trim Input Gain 0	Controls the input gain adjustment for input channel 0.
Trim Input Offset 0	Controls the input level offset adjustment for input channel 0.
Trim Input Gain 1	Controls the input gain adjustment for input channel 1.
Trim Input Offset 1	Controls the input level offset adjustment for input channel 1.
Temperature	Two-byte register containing a 12-bit temperature reading for calibrating the S16A for different operating temperatures.

Table 12. Analog Input Module Internal Registers

Input Clock Prescale Registers

The Analog Input Module contains two 1-byte Input Clock Prescale registers (one for each input channel) that provide 1-biased divisors for the input clock, which has a base rate of 192 KHz. The low 3 bits of these registers are significant. Thus, the input sample rate for each channel is

$$192 \text{ KHz} / (\text{value} + 1)$$

where

value is the channel's Input Clock Prescale register value, which can range from 0 to 7.

As Analog Input Module registers, these registers are accessed via the UART registers.

Input Configuration Registers

The Analog Input Module contains two two-byte Input Configuration registers, one each for the two input channels. The low-order byte controls the input source; the high byte provides a primary gain control. The following two tables list the useful values for the low and high bytes. One value from each table must be chosen and bitwise ORed together to configure this register.

As Analog Input Module registers, these registers are accessed via the UART registers.

Value (hex)	AIN_	Description
xx42	DIFFERENTIAL	Both input pins for this channel are monitored as a differential signal.
xx48	PLUS_ONLY	The "plus" input pin for this channel is monitored as a single-ended signal.
xx82	MINUS_ONLY	The "minus" input pin for this channel is monitored as a single-ended signal.
xx88	ZERO	The input is taken from ground. Used for offset calibration.
xx48	OUT0_PLUS	The "plus" signal from output channel 0 is monitored as a single-ended signal.
xx84	OUT0_MINUS	The "minus" signal from output channel 0 is monitored as a single-ended signal.
xx18	OUT1_PLUS	The "plus" signal from output channel 1 is monitored as a single-ended signal.
xx82	OUT1_MINUS	The "minus" signal from output channel 1 is monitored as a single-ended signal.

Table 13. Input Selection (Low Byte) Values

Value (hex)	AIN_	Description
08xx	X1	Unit gain.
09xx	X2	Gain factor 2.
0Axx	X5	Gain factor 5.
0Cxx	X10_1	First gain factor 10. Uses the first-stage gain at maximum.
10xx	X10_2	Second gain factor 10. Uses the second-stage 10 x gain. Recommended for higher bandwidth.
11xx	X20	Gain factor 20.
12xx	X50	Gain factor 50.
14xx	X100	Gain factor 100. Uses both stages at maximum.

Table 14. Input Gain (High Byte) Values

Trim Registers

The Analog Input Module contains six Digital-to-Analog converters (DACs) that control various trim adjustments on the S16A. The analog input and output signals can be level-shifted, and the input signal gains can be fine-tuned with these DACs. These trim DACs are controlled by six 8-bit trim registers. These trim registers are set with the **D** command, described in **Analog Input Module Control Protocol** beginning on page 34.

As Analog Input Module registers, these registers are accessed via the UART registers.

Trim Register	Use
2	controls the output trim for analog I/O channel 0
3	controls the output trim for analog I/O channel 1
4	controls the input gain trim for analog I/O channel 0
5	controls the input offset for analog I/O channel 0
6	controls the input gain trim for analog I/O channel 1
7	controls the input offset for analog I/O channel 1

Table 15. Trim Registers

Trim Output Offset Registers

These two trim registers control a voltage offset for the output of each analog I/O channel. Trim register 2 controls the output trim for analog I/O channel 0; trim register 3 controls the output trim for channel 1.

The recommended procedure for adjusting these output trim registers is to first adjust one of the analog I/O channels' input offset to be zero-calibrated by configuring its input to be ground and adjusting its input offset while monitoring the input data for zero. After setting up one of the analog I/O channels as a calibrated input, reconfigure the analog I/O channel input to monitor the analog I/O channel output in question. Finally, with all zeros for the output data, adjust the output trim until zeros are read in the input channel.

Trim Input Gain Registers

These two trim registers control the fine-tuning of the analog I/O input gain. Trim register 4 controls the gain trim for analog I/O channel 0 input; trim register 6 controls the gain trim for channel 1 input. The input offset should be set using a zero-level input signal before setting the input gain.

Trim Input Offset Registers

These two trim registers control the fine-tuning of the input gain. Trim register 5 controls the input offset for analog I/O channel 0; trim register 7 controls the input offset for analog I/O channel 1.

The recommended procedure for adjusting these input trim registers is to connect it to the signal source, set the source to generate a zero-level signal, and then adjust the input offset while monitoring the input data for zero. The input offset trim should be set using a zero-level input signal before configuring the input gain and input gain trim settings.

Temperature Register

The S16A contains an internal temperature probe that can be read via the Analog Input Module UART interface to provide data for temperature-dependent calibration adjustments. This two-byte register returns a 12-bit reading that can be converted to a Celsius temperature using the formula

$$C = ((5.0 * (r / 4096)) - 1.375) * 0.0225$$

where

r is the raw temperature reading, and

C is the resulting Celsius temperature.

As an Analog Input Module register, this register is accessed via the UART registers.

Analog Input Module UART Registers

The S16A Analog Input Module is configured and controlled by a byte stream protocol via two UART registers on the SBus. Command sequences of bytes are sent to the module, which in turn responds with byte sequences. Two interface registers, the UART CSR and the UART Data register, implement this byte stream interface on the SBus.

Analog Input Module Control Protocol

All command and status sequences consist entirely of printable ASCII characters. Commands are case-insensitive. The command character is always echoed; valid arguments are also echoed; invalid argument characters are ignored. Commands are not terminated with a carriage return or newline: when the last character of the command is sent, the command is immediately executed and the response string is sent back.

Write to a Clock Prescale Register

The clock prescale registers are written by sending a four-byte sequence beginning with **W** or **w**.

Wnmm Write an 8-bit value to a Clock Prescale register.

n Number of the Clock Prescale register to be written. 0 is input channel 0; 1 is input channel 1.

mm Hexadecimal value to write to the register.

The UART responds with the four-character sequence **return linefeed > space**.

Write to an Input Configuration Register

The input configuration registers are written by sending a six-byte sequence beginning with **W** or **w**.

Wnmmmm Write a 16-bit value to an Input Configuration register.

n Number of the Input Configuration register to be written. 2 is input channel 0; 3 is input channel 1.

mmmm Hexadecimal value to write to the register.

The UART responds with the four-character sequence **return linefeed > space**.

Read from a Clock Prescale Register

The Clock Prescale registers are read by sending a two-byte sequence beginning with **R** or **r**.

Rn Read an 8-bit value from a Clock Prescale register.

n Number of the Clock Prescale register to be read. 0 is input channel 0; 1 is input channel 1.

The UART responds with the six-character sequence **xx return linefeed > space**, where **xx** is the two-character hexadecimal value read from the 8-bit register.

Read from an Input Configuration Register

The Input Configuration registers are read by sending a two-byte sequence beginning with **R** or **r**.

Rn Read a 16-bit value from a Input Configuration register.

n Number of the Input Configuration register to be written. 2 is input channel 0; 3 is input channel 1.

The UART responds with the eight-character sequence **xxxx return linefeed > space**, where **xxxx** is the four-character hexadecimal value read from the 16-bit register.

Write to a Trim Register

The trim registers are written by sending a four-byte sequence beginning with **D** or **w**.

Dnmm Write an 8-bit value to a trim register.

n Number of the trim register to be written:

- 2 Output 0 offset
- 3 Output 1 offset
- 4 Input 0 gain trim
- 5 Input 0 offset
- 6 Input 1 gain trim
- 7 Input 1 offset

mm Hexadecimal value to write to the register.

The UART responds with the four-character sequence **return linefeed > space**.

Read the Temperature Register

The Temperature register is read by sending a one-byte command: **T** or **t**.

T Read the Temperature register.

The UART responds with the seven-character sequence **xxx return linefeed > space**, where **xxx** is the three-character hexadecimal value. See **Temperature Register** beginning on page 34 for details on how to interpret this value.

UART Command/Status Register

The UART CSR is an 8-bit register at 0400C0x. This register controls the serial byte-stream protocol used to configure and control the internal analog input module.

Bit	S16A_	Description
7	UART_INT	A read-only status bit. A value of 1 indicates the S16A UART is asserting an SBus interrupt.
6		Unused. 0 when read.
5	UART_TXBSY	A read-only status bit. A value of 1 indicates the S16A UART is currently transmitting a command byte to the analog input module. No other bytes can be sent until this bit is clear.
4	UART_RXRDY	A read-only status bit. A value of 1 indicates the S16A UART has received a status byte from the analog input module. Valid status bytes can only be read from the UART_DATA register when this bit is set.
3	UART_TXINT	A value of 1 enables the UART transmit complete interrupt.
2	UART_RXINT	A value of 1 enables the UART receive complete interrupt.
1-0		Unused. 0 when read.

Table 16. UART Command/Status Register

UART Data Register

The UART Data register is an 8-bit register at address 0400C4x. This register provides the byte stream for communicating with the analog input module. Write to this register (when the UART CSR indicates that it is ready for a write) to send a byte to the Analog Input Module. Read this register to receive status bytes from the Analog Input Module when the UART CSR indicates that a received byte is available.

Xilinx Programming Registers

The Xilinx programming registers are 3 8-bit registers at addresses 0x20000, 0x20004, and 0x20008. The Xilinx chip is a programmable integrated circuit used to implement the S16A interface or to test the board.

NOTE: Any registers defined to control the interface reside in the Xilinx IC. In order to access those registers, the S16A board requires that the Xilinx be loaded with a program that defines them. If the Xilinx is not loaded, or loaded with an incorrect program, those registers are inaccessible.

The Xilinx IC is programmed when the S16A driver is loaded. User applications should not access the Xilinx registers.

Specifications

The SBus 16-bit Dual Analog Interface conforms to the following specifications.

SBus Compliance

Number of slots:	1
Transfer size	Input: 1 word per transfer Output: 4 words per transfer
DVMA master	
SBus memory space	approx. 320 KBytes
Clock rate	25 MHz

Software

Drivers for Sun OS Version 4.1.3 or later and System V Version 4 (Solaris 2.4 or later)

Power

5 V at 2 A

Environmental

Temperature	Operating: 10 to 40 C Nonoperating: -20 to 60 C
Humidity	Operating: 20 to 80% noncondensing at 40 C Nonoperating: 95% noncondensing at 40 C

Physical

Dimensions	3.3" x 5.78" x 0.5"
Weight	3.5 oz.

References

The following additional documentation may prove helpful.

Burr-Brown PCM1702 product specification, in *Burr-Brown Integrated Circuits Data Book, Data Conversion Products 1995*, pp. 8.2.108 to 8.2.115. Available from Burr-Brown Corporation, (800) 548-6132.

National Semiconductor ADC16071 product specification, in *National Data Acquisition Databook 1995 Edition*, pp. 2-672 to 2-689. Available from National Semiconductor Corporation, (800) 272-9959.

Sun *SBus Specification B.0*, part number 800-5323-05, available from Sun Microsystems, Inc., (415) 960-1300.

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In addition, a variety of services, from sales information to updated manuals to technical support, is available through EDT's World Wide Web site, at

<http://www.edt.com>

If you have had the board for a period of time before installing it, we recommend you get the latest software over the internet to ensure you have all the latest enhancements. You can either do this by accessing our World Wide Web page, and selecting **Technical Support**, then **Software**, then specifying which operating system version and driver to download. Alternately, you can use *ftp* to get the software directly using the following procedure:

1. FTP to the EDT ftp server by typing

```
ftp ftp.edt.com
```

2. Login as anonymous. The password is your e-mail address.
3. Change to the appropriate directory for the version of the operating system you are running. If you are running SunOS 4.1.3 or later, type

```
cd /pub/s16a/4x
```

If you are running SunOS 5.x (Solaris 2.4 or later), type

```
cd /pub/s16a/5x
```

4. Set binary transfer mode by typing
5. Download the software and README file:

```
get EDTs16a.tar.Z
```

```
get README
```

6. Exit ftp:

```
quit
```

7. Follow the instructions in the README file to extract and install the software from the .z file.

The latest release of this manual is also available, via the World Wide Web site under **Technical Support, Manuals**, or via ftp to ftp.edt.com in */pub/manuals/s16a.ps.Z* (postscript format, compressed).

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