

Linux-GPIB 4.2.0 Documentation

Copyright © 2003-2006, 2008 Frank Mori Hess

Permission is granted to copy, distribute and/or modify this document under the terms of the GNU Free Documentation License, Version 1.2 or any later version published by the Free Software Foundation; with no Invariant Sections, no Front-Cover Texts, and no Back-Cover Texts. A copy of the license is included in the section entitled **GNU Free Documentation License**.

Alternatively, you may redistribute and/or modify this document under the terms of the GNU General Public License as published by the Free Software Foundation; either version 2 of the License, or (at your option) any later version.

COLLABORATORS

	<i>TITLE :</i> Linux-GPIB 4.2.0 Documentation		
<i>ACTION</i>	<i>NAME</i>	<i>DATE</i>	<i>SIGNATURE</i>
WRITTEN BY	Frank Mori Hess and Dave Penkler	March 13, 2019	

REVISION HISTORY

NUMBER	DATE	DESCRIPTION	NAME
1	2018-06-16	Update to DocBook 5, add ibterm manpage	Colin Samples

Contents

1	Copying	1
2	Configuration	1
2.1	ibterm	1
2.2	gpib.conf	3
2.3	gpib_config	5
3	Supported Hardware	6
3.1	Supported Hardware Matrix	6
3.2	Board-Specific Notes	8
3.2.1	Agilent (HP) 82341	8
3.2.2	Agilent 82350A/B and 82351A	8
3.2.3	Agilent 82357A/B	8
3.2.4	Beiming F/S82357	9
3.2.5	fmh_gpib_core	9
3.2.6	Self-made usb-gpib adapter	9
3.2.7	National Instruments GPIB-USB-B	9
3.2.8	National Instruments GPIB-USB-HS and GPIB-USB-HS+	10
4	Linux-GPIB Reference	10
4.1	Global Variables	10
4.1.1	ibcnt and ibcntl	10
4.1.2	iberr	10
4.1.3	ibsta	12
4.2	“Traditional” API Functions	14
4.2.1	ibask	14
4.2.2	ibbna	16
4.2.3	ibcac	16
4.2.4	ibclr	17
4.2.5	ibcmd	17
4.2.6	ibcmnda	18
4.2.7	ibconfig	18
4.2.8	ibdev	21
4.2.9	ibeos	21
4.2.10	ibeot	22
4.2.11	ibevent	22
4.2.12	ibfind	23
4.2.13	ibgts	23

4.2.14	ibist	24
4.2.15	iblines	24
4.2.16	ibln	25
4.2.17	ibloc	26
4.2.18	ibonl	26
4.2.19	ibpad	26
4.2.20	ibpct	27
4.2.21	ibppc	27
4.2.22	ibrd	28
4.2.23	ibrda	28
4.2.24	ibrdf	29
4.2.25	ibrpp	29
4.2.26	ibrsc	29
4.2.27	ibrsp	30
4.2.28	ibrsv	31
4.2.29	ibsad	31
4.2.30	ibsic	32
4.2.31	ibspb	32
4.2.32	ibsre	32
4.2.33	ibstop	33
4.2.34	ibtmo	33
4.2.35	ibtrg	34
4.2.36	ibvers	34
4.2.37	ibwait	35
4.2.38	ibwrt	35
4.2.39	ibwrta	36
4.2.40	ibwrtf	36
4.3	“Multidevice” API Functions	37
4.3.1	AllSPoll	37
4.3.2	DevClear	37
4.3.3	DevClearList	37
4.3.4	EnableLocal	38
4.3.5	EnableRemote	38
4.3.6	FindLstn	38
4.3.7	FindRQS	39
4.3.8	PassControl	39
4.3.9	PPoll	39
4.3.10	PPollConfig	40
4.3.11	PPollUnconfig	40

4.3.12	RcvRespMsg	40
4.3.13	ReadStatusByte	41
4.3.14	Receive	41
4.3.15	ReceiveSetup	41
4.3.16	ResetSys	42
4.3.17	Send	42
4.3.18	SendCmds	42
4.3.19	SendDataBytes	43
4.3.20	SendIFC	43
4.3.21	SendList	44
4.3.22	SendLLO	44
4.3.23	SendSetup	44
4.3.24	SetRWLS	45
4.3.25	TestSRQ	45
4.3.26	TestSys	45
4.3.27	Trigger	46
4.3.28	TriggerList	46
4.3.29	WaitSRQ	46
4.4	Utility Functions	46
4.4.1	AsyncIbent and AsyncIbentl	46
4.4.2	AsyncIberr	47
4.4.3	AsyncIbsta	47
4.4.4	GetPAD	48
4.4.5	GetSAD	48
4.4.6	MakeAddr	49
4.4.7	MLA	49
4.4.8	MSA	50
4.4.9	MTA	50
4.4.10	PPE_byte	50
4.4.11	ThreadIbent and ThreadIbentl	51
4.4.12	ThreadIberr	51
4.4.13	ThreadIbsta	52
5	GPIB protocol	52
5.1	GPIB command bytes	52
5.2	GPIB bus lines	53

A	GNU Free Documentation License	54
A.1	PREAMBLE	54
A.2	APPLICABILITY AND DEFINITIONS	54
A.3	VERBATIM COPYING	55
A.4	COPYING IN QUANTITY	55
A.5	MODIFICATIONS	56
A.6	COMBINING DOCUMENTS	57
A.7	COLLECTIONS OF DOCUMENTS	57
A.8	AGGREGATION WITH INDEPENDENT WORKS	57
A.9	TRANSLATION	58
A.10	TERMINATION	58
A.11	FUTURE REVISIONS OF THIS LICENSE	58
A.12	ADDENDUM: How to use this License for your documents	58

List of Tables

1 Copying

Permission is granted to copy, distribute and/or modify this document under the terms of the GNU Free Documentation License, Version 1.2 or any later version published by the Free Software Foundation; with no Invariant Sections, no Front-Cover Texts, and no Back-Cover Texts. A copy of the license is included in the section entitled [GNU Free Documentation License](#).

Alternatively, you may redistribute and/or modify this document under the terms of the GNU General Public License as published by the Free Software Foundation; either version 2 of the License, or (at your option) any later version.

2 Configuration

Configuration of the GPIB library is accomplished through the configuration file `/etc/gpib.conf`, and the administration program [gpib_config](#).

2.1 ibterm

`ibterm` — Interactive GPIB terminal

Synopsis

```
ibterm -d primary_address [-m minor] [-s secondary_address] [-i eoi] [-e eos] [-r reos] [-b bin] [-x xeos] [-t timeout] [-p prompt] [-f history_file] [-N] [-X] [-h]
```

Description

An interactive terminal program for sending commands to a device over an IEEE-488 general purpose instrument bus and printing the responses.

Options

- d *address*** Sets the device's primary address (*pad*). The *address* must be between 0 and 30.
- m *number*** Specify the minor number of the device file this interface board will use. A *number* of 0 corresponds to `/dev/gpib0`, 1 is `/dev/gpib1`, etc. Defaults to 0.
- s *address*** Sets the device's secondary address (*sad*). The *address* must be 0 (disabled) or between 96 and 126 (0x60 and 0x7e hexadecimal). Defaults to 0.
- i 0/1** Assert EIO with last byte sent. Defaults to 1 (true).
- e *code*** ASCII code of end-of-string (*eo*s) character. The *code* must be between 0 and 255. Defaults to 0 (no code).
- r 0/1** Terminate read on eos character (*re*os) flag. Defaults to 0 (false).
- b 0/1** Binary eos character match mode (*bin*) flag. Defaults to 0 (false).
- x 0/1** Assert EOI when transmitting eos (*xe*os) flag. Defaults to 0 (false).
- t *timeout*** Sets the IO timeout for the device. The *timeout* must be a value from the below table. The default value is 10, corresponding to 300 milliseconds.

<i>timeout</i>	Length
0	Never timeout
1	10 microseconds
2	30 microseconds

<i>timeout</i>	Length
3	100 microseconds
4	300 microseconds
5	1 millisecond
6	3 milliseconds
7	10 milliseconds
8	30 milliseconds
9	100 milliseconds
10	300 milliseconds
11	1 second
12	3 seconds
13	10 seconds
14	30 seconds
15	100 seconds
16	300 seconds
17	1000 seconds

-p *string* Sets the prompt. Defaults to “ibterm>”

-f *file* Command history file. Defaults to “.ibterm_hist_<primary_address>”

-N No automatic read on device, enter **return** at prompt to read.

-X Force hexadecimal output.

-h Print help and exit.

Notes

To quit the program enter the EOF character (Ctrl-D) at the prompt.

For interactivity, *timeout* should not be greater than 13 i.e. 10 secs.

A device read can always be triggered by hitting **enter** at the prompt. Interrupting the program while reading from the device may cause hangs.

Implementation details

The program is implemented as follows:

```

loop:
    Print prompt to stdout
    Read a line of text from stdin
    Write the text (if any) to the device at pad
    If -N is not set, or no text was entered:
        Attempt to read response from the device
        If no response is received before timeout:
            go to loop
        else:
            print the response on stdout
    Go back to loop.
```

See also

See the readline(3) man page for editing input and searching history.

2.2 gpib.conf

gpib.conf — GPIB library configuration file

Description

The library, and the administration tool **gpib_config**(8), read their configuration information from the file `/etc/gpib.conf`. A template `gpib.conf` file can be found in the `util/templates/` subdirectory of the `linux-gpib` package.

The configuration file must contain one or more “interface” entries, and can contain zero or more “device” entries. “device” entries are only required if you wish to open device descriptors with **ibfind()** instead of using **ibdev()**. Several example entries, and a table summarizing the possible options follow.

```
interface {
    minor = 0
    board_type = "ni_pci"
    pad = 0
    master = yes
}

interface {
    minor = 1
    board_type = "ines_pci"
    name = "joe"
    pad = 5
    sad = 0
    timeout = T10s
    pci_bus = 0
    pci_slot = 0xd
    master = no
}

interface {
    minor = 2
    board_type = "pcII"
    pad = 3
    sad = 0x62
    eos = 0x0d
    set-reos = yes
    set-bin = no
    set-xeos = no
    set-eot = yes
    base = 0x300
    irq = 5
    dma = 0
    master = no
}

device {
    minor = 0
    name = "counter"
    pad = 24
}

device {
    minor = 0
    name = "voltmeter"
    pad = 7
    sad = 110
    eos = 0xa
    set-reos = yes
}
```

```

set-bin = no
set-xeos = yes
set-eot = no
timeout = 11s
}

```

option name	description	used by interface or device entries
base	Specifies the base ioport or io memory address for a board that lacks plug-and-play capability.	interface
board_type	Specifies the type of interface board. See the drivers.txt file for a list of possible board types, and the kernel driver module that supports them.	interface
device_tree_path	A string which may be used to select a particular piece of hardware by its full device tree path.	interface
dma	Specifies the dma channel for a board that lacks plug-and-play capability.	interface
eos	Sets the end-of-string byte for board or device descriptors obtained with <code>ibfind()</code> . See also the <code>set-reos</code> , <code>set-bin</code> , and <code>set-xeos</code> options.	interface or device
irq	Specifies the interrupt level for a board that lacks plug-and-play capability.	interface
master	Set to “yes” if you want the interface board to be the system controller of the bus. There can only be one system controller on a bus.	interface
minor	“minor” specifies the minor number of the device file this interface board will use. A “minor” of 0 corresponds to <code>/dev/gpib0</code> , 1 is <code>/dev/gpib1</code> , etc. The minor number is also equal to the “board index” which can be used as a board descriptor, and is passed as one of the arguments of <code>ibdev()</code>	interface
name	The “name” specifies the name which can be used with <code>ibfind()</code> to get a descriptor for the board or device associated with this entry.	interface or device
pad	Specifies the primary GPIB address (valid addresses are 0 to 30). For interfaces, this is the primary address that the board will be assigned when it is first brought online. For devices, this is address that will be used by device descriptors obtained with <code>ibfind()</code> .	interface or device
pci_bus	Useful for distinguishing between multiple PCI cards. If you have more than one PCI card that with the same “board_type”, you can use the “pci_bus” and “pci_slot” options to specify the particular card you are interested in.	interface

option name	description	used by interface or device entries
pci_slot	Can be used in conjunction with “pci_bus” to specify a particular pci card.	interface
sad	Specifies the secondary GPIB address. Valid values are 0, or 0x60 to 0x7e hexadecimal (96 to 126 decimal). A value of 0 means secondary addressing is disabled (the default). Secondary addresses from 0 to 30 are specified by the library’s convention of adding an offset of 0x60.	interface or device
set-bin	Enables 8-bit comparisons when matching the end-of-string byte, instead of only comparing the 7 least significant bits. Only affects descriptors returned by <code>ibfind()</code> , and has same effect as setting the BIN bit in a <code>ibeos()</code> call.	interface or device
set-eot	Enables assertion of the EOI line at the end of writes, for descriptors returned by <code>ibfind()</code> . See <code>ibeot()</code> .	interface or device
set-reos	Enables the termination of reads on reception of the end-of-string byte for descriptors returned by <code>ibfind()</code> . Same as setting the REOS bit in a <code>ibeos()</code> call.	interface or device
set-xeos	Enables the assertion of EOI on transmission of the end-of-string byte for descriptors returned by <code>ibfind()</code> . Same as setting the XEOS bit in a <code>ibeos()</code> call.	interface or device
timeout	Sets the io timeout for a board or device descriptor opened through <code>ibfind()</code> . The possible settings are the same as the constants used by <code>ibtmo()</code> .	interface or device

2.3 gpib_config

gpib_config — GPIB administration program

Synopsis

```
gpib_config [--minor number]
```

```
gpib_config [--board-type board_type] [--dma number] [--file file_path] [--iobase number] [--ifc] [--no-ifc] [--irq number] [--minor number] [--pad number] [--pci-bus number] [--pci-slot number] [--sad number] [--sre] [--no-sre] [--system-controller] [--no-system-controller] [--version]
```

Description

gpib_config must be run after the kernel driver module for a GPIB interface board is loaded. It performs configuration of driver settings that cannot be performed by `libgpib` at runtime. This includes configuration which requires root privilege (for

example, setting the base address or irq of a board), and configuration which should only be performed once and not automatically redone every time a program using `libgpiib` is run (for example, setting the board's GPIB address).

The board to be configured by `gpiib_config` is selected by the `--minor` option. By default, the board settings are read from the `gpiib.conf(5)` configuration file. However, individual settings can be overridden by use of command-line options (see below).

Options

- b, --iobase *number*** Set io base address to *number* for boards without plug-and-play capability.
- d, --dma *number*** Specify isa dma channel *number* for boards without plug-and-play capability.
- I, --init-data *file_path*** Upload binary initialization data (firmware) from *file_path* to board.
- i, --irq *number*** Specify irq line *number* for boards without plug-and-play capability.
- f, --file *file_path*** Specify file path for configuration file. The values in the configuration file will be used as defaults for unspecified options. The default configuration file is `/etc/gpiib.conf`.
- h, --help** Print help on options and exit.
- l, --pci-slot *number*** Specify pci slot *number* to select a specific pci board. If used, you must also specify the pci bus with `--pci-bus`.
- m, --minor *number*** Configure gpiib device file with minor number *number* (default is 0).
- p, --pad *number*** Specify primary gpiib address. *number* should be in the range 0 through 30.
- s, --sad *number*** Specify secondary gpiib address. *number* should be 0 (disabled) or in the range 96 through 126 (0x60 through 0x7e hexadecimal).
- t, --board-type *board_type*** Set board type to *board_type*.
- u, --pci-bus *number*** Specify pci bus *number* to select a specific pci board. If used, you must also specify the pci slot with `--pci-slot`.
- v, --version** Prints the current `linux-gpiib` version and exits.
- [no-]ifc** Perform (or not) interface clear after bringing board online. Default is `--ifc`.
- [no-]sre** Assert (or not) remote enable line after bringing board online. Default is `--sre`.
- [no-]system-controller** Configure board as system controller (or not).

3 Supported Hardware

3.1 Supported Hardware Matrix

make	model	kernel driver module	board_type (for <code>/etc/gpiib.conf</code>)
Agilent (HP)	82341C	hp_82341.ko	hp_82341
Agilent (HP)	82341D	hp_82341.ko	hp_82341
Agilent (HP)	82350A	agilent_82350b.ko	agilent_82350b
Agilent	82350B	agilent_82350b.ko	agilent_82350b
Agilent	82351A	agilent_82350b.ko	agilent_82350b
Agilent	82357A	agilent_82357a.ko	agilent_82357a
Agilent	82357B	agilent_82357a.ko	agilent_82357a
Beiming Technologies	F82357	agilent_82357a.ko	agilent_82357a
Beiming Technologies	S82357	agilent_82357a.ko	agilent_82357a

make	model	kernel driver module	board_type (for /etc/gpib.conf)
Capital Equipment Corporation	PC-488	pc2_gpib.ko	pcII
Capital Equipment Corporation	PCI-488	cec_gpib.ko	cec_pci
Capital Equipment Corporation	CEC-488	tnt4882.ko	ni_pci
CONTEC	GP-IB(PC)	pc2_gpib.ko	pcIIa
Frank Mori Hess	fmh_gpib_core	fmh_gpib.ko	fmh_gpib, fmh_gpib_unaccel
Hameg	HO80	pc2_gpib.ko	pcII
Hameg	HO80-2	ines_gpib.ko	ines_isa
Hewlett Packard	HP82335	hp82335.ko	hp82335
Hewlett Packard	HP27209	hp82335.ko	hp82335
Ines	GPIB-HS-NT	ines_gpib.ko	ines_isa
Ines	GPIB for Compact PCI	ines_gpib.ko	ines_pci, ines_pci_unaccel
Ines	GPIB for PCI	ines_gpib.ko	ines_pci, ines_pci_unaccel
Ines	GPIB for PCMCIA	ines_gpib.ko	ines_pcmcia, ines_pcmcia_unaccel
Ines	GPIB PC/104	ines_gpib.ko	ines_isa
Iotech	GP488B	pc2_gpib.ko	pcIIa
Keithley	KPCI-488	cec_gpib.ko	cec_pci
Keithley	KUSB-488	ni_usb_gpib.ko	ni_usb_b
Keithley	KUSB-488A	ni_usb_gpib.ko	ni_usb_b
Keithley	MBC-488	pc2_gpib.ko	pcII
Keysight (Agilent)	82350B PCI	agilent_82350b.ko	agilent_82350b
Keysight (Agilent)	82351A PCIe	agilent_82350b.ko	agilent_82350b
Keysight (Agilent)	82357B USB	agilent_82357a.ko	agilent_82357a
Measurement Computing (Computer Boards)	CPCI-GPIB	cb7210.ko	cbi_pci, cbi_pci_unaccel
Measurement Computing (Computer Boards)	ISA-GPIB	cb7210.ko	cbi_isa, cbi_isa_unaccel
Measurement Computing (Computer Boards)	ISA-GPIB/LC	cb7210.ko	cbi_isa_unaccel
Measurement Computing (Computer Boards)	ISA-GPIB-PC2A	pc2_gpib.ko	pcIIa (nec7210 chip), pcIIa_cb7210 (cb7210 chip)
Measurement Computing (Computer Boards)	PCI-GPIB/1M	cb7210.ko	cbi_pci, cbi_pci_unaccel
Measurement Computing (Computer Boards)	PCI-GPIB/300K	cb7210.ko	cbi_pci_unaccel
Measurement Computing (Computer Boards)	PCMCIA-GPIB	cb7210.ko	cbi_pcmcia, cbi_pcmcia_unaccel
Measurement Computing (Computer Boards)	USB-488	ni_usb_gpib.ko	ni_usb_b
National Instruments	AT-GPIB (with NAT4882 chip)	tnt4882.ko	ni_nat4882_isa, ni_nat4882_isa_accel
National Instruments	AT-GPIB (with NEC7210 chip)	tnt4882.ko	ni_nec_isa, ni_nec_isa_accel
National Instruments	AT-GPIB/TNT	tnt4882.ko	ni_isa, ni_isa_accel
National Instruments	GPIB-USB-B	ni_usb_gpib.ko	ni_usb_b
National Instruments	GPIB-USB-HS	ni_usb_gpib.ko	ni_usb_b
National Instruments	GPIB-USB-HS+	ni_usb_gpib.ko	ni_usb_b
National Instruments	PCI-GPIB	tnt4882.ko	ni_pci
National Instruments	PCI-GPIB+	tnt4882.ko	ni_pci
National Instruments	PCM-GPIB	tnt4882.ko	ni_pci
National Instruments	PXI-GPIB	tnt4882.ko	ni_pci

make	model	kernel driver module	board_type (for /etc/gpib.conf)
National Instruments	PCII	pc2_gpib.ko	pcII
National Instruments	PCIIa	pc2_gpib.ko	pcIIa
National Instruments	PCII/IIa	pc2_gpib.ko	pcII or pcII_IIa (depending on board switch)
National Instruments	PCMCIA-GPIB	tnt4882.ko	ni_pcmcia, ni_pcmcia_accel
self-made (see note)	http://lpvo.fe.uni-lj.si/gpib	lpvo_usb_gpib.ko	lpvo_usb_gpib
Quamcom	PCIGPIB-1	ines_gpib.ko (Ines iGPIB 72010 chip) or cb7210.ko (Measurement Computing cb7210 chip)	ines_pci or ines_pci_unaccel (Ines iGPIB 72010 chip), cbi_pci_unaccel (Measurement Computing cb7210 chip)

3.2 Board-Specific Notes

3.2.1 Agilent (HP) 82341

After power-up, the Agilent 82341 boards require a firmware upload before they can be used. This can be accomplished using the `--init-data` option of **gpib_config**. The firmware data can be found in the `gpib_firmware` tarball available from the [Linux-GPIB home page](#). Note the C and D versions use different firmware data.

If you specify a non-zero base address in `/etc/gpib.conf`, the driver will assume you are trying to configure a 82341C. Otherwise, the driver will use the kernel's ISAPNP support to attempt to configure an 82341D.

The 82341 does not support detection of an end-of-string character in hardware, it only automatically detects the when the EOI line is asserted. Thus if you use the REOS flag for a read, the board's fifos will not be used for the transfer. This will greatly reduce the maximum transfer rate for your board (which may or may not be noticeable depending on the device you are talking to).

3.2.2 Agilent 82350A/B and 82351A

The Agilent 82350A/B and 82351A boards do not support detection of an end-of-string character during reads in hardware, they can only detect assertion of the EOI line. Thus if you use the REOS flag for a read, the boards' fifos will not be used for the transfer. This will greatly reduce the maximum transfer rate for your board (which may or may not be noticeable depending on the device you are talking to).

After power-up, the 82350A boards require a firmware upload before they can be used. This can be accomplished using the `--init-data` option of **gpib_config**. The firmware data can be found in the `gpib_firmware` tarball available from the [Linux-GPIB home page](#). The 82350B and 82351A do not require a firmware upload.

3.2.3 Agilent 82357A/B

The Agilent 82357A and 82357B require a firmware upload (before **gpib_config** is run) to become functional after being plugged in. The `linux-gpib` tarball contains hotplug scripts for automatically running the `fxload` program to upload the firmware (and to run **gpib_config** after the firmware is uploaded). However, the actual firmware data itself must be obtained separately, as part of the `gpib_firmware` tarball available from the [Linux-GPIB home page](#).

The 82357A/B have a few limitation due to their firmware code:

- They cannot be run as a device, but must be the system controller.
- They cannot be assigned a secondary address.
- They cannot do 7 bit compares when looking for an end-of-string character (they always compare all 8 bits).

3.2.4 Beiming F/S82357

Linux_gplib support requires a minimum firmware version of 1.10 for the F82357 and version 1.20 for the S82357. These devices have on-board firmware and do not require a firmware upload before becoming functional after plug-in. The on-board firmware can be re-flashed; contact the manufacturer for firmware and re-flash procedure.

Limitations:

- These devices can only be used as system controllers.
- They can only do 8-bit end-of-string (EOS) compares.

3.2.5 fmh_gplib_core

fmh_gplib_core is a GPIB chip written in VHDL suitable for programming into a FPGA. The code for the chip may be found at https://github.com/fmhess/fmh_gplib_core. It supports a cb7210.2 style register interface with some extensions. More specifically, the driver is for the hardware layout specified in src/example/fmh_gplib_top.vhd file in the fmh_gplib_core repository.

The driver obtains its hardware information (base addresses, interrupt, dma, etc.) from the device tree. It expects to find two i/o memory resources, an interrupt, and a dma channel. One i/o memory resource is called “gplib_control_status” which contains the 8 bit cb7210.2 registers. The other i/o memory resource is called “dma_fifos” and contains 16 bit registers for the fifos and transfer counter. The dma channel the chip is wired to is specified with the standard “dmass” and “dma-names” fields, with a dma-name of “rxtx”. So, the device tree entry for a chip connected to channel 2 of dma controller “dmac” might look something like:

```
fmh_gplib_0: fmh_gplib@0x00049800 {
    compatible = "fmhess,fmh_gplib_core";
    reg = > 0x00049600 0x00000080
          0x00049800 0x00000008 >;
    reg-names = "gplib_control_status", "dma_fifos";
    interrupt-parent = < &intc >;
    interrupts = < 0 57 4 >;
    dmass = < &dmac 2 >;
    dma-names = "rxtx";
}; //end fmh_gplib@0x00049800 (fmh_gplib_0)
```

3.2.6 Self-made usb-gplib adapter

This usb-gplib adapter can be assembled following the project from the Laboratory of Photovoltaics and Optoelectronics at the Faculty of Electrical Engineering, University of Ljubljana. It is available at <http://lpvo.fe.uni-lj.si/gplib>. The adapter allows the control of GPIB devices with some limitations: it can only be the system controller; multicontroller and device operations are not supported (as yet). The linux-gplib driver “lpvo_usb_gplib”, written at the Department of Physics of University of Florence (Italy), is currently under development. It offers basic capabilities like ibrd(), ibwrt(), WaitSRQ() and others. Requests for unsupported features are flagged by a diagnostic message to syslog.

The driver assumes by default that the adapter is connected to port ttyUSB0. It is possible to change the 0 into any value *n* in the range 0-99 with the **gplib_config** option **-b n** (or **base = n** in the configuration file). Currently there is no way for the kernel to know that a gplib adapter of this kind is available, hence the following commands have to be entered manually (as root), before **gplib_config** (*n* is the port number as before)

```
modprobe lpvo_usb_gplib
stty raw -echo -iexten -F /dev/ttyUSBn
gplib_config ...
```

3.2.7 National Instruments GPIB-USB-B

The USB-B requires a firmware upload (before **gplib_config** is run) to become functional after being plugged in. The linux-gplib tarball contains hotplug scripts for automatically running the fxload program to upload the firmware (and to run **gplib_config** after the firmware is uploaded). However, the actual firmware data itself must be obtained separately, as part of the gplib_firmware tarball available from the [Linux-GPIB home page](#).

3.2.8 National Instruments GPIB-USB-HS and GPIB-USB-HS+

Unlike the USB-B, the USB-HS and USB-HS+ do not require a firmware upload to become functional after being plugged in. The linux-gpib tarball contains hotplug scripts which will automatically run **gpib_config** after the device is plugged in.

4 Linux-GPIB Reference

Reference for libgpib functions, macros, and constants.

4.1 Global Variables

4.1.1 ibcnt and ibcntl

ibcnt and ibcntl — hold number of bytes transferred, or errno

Synopsis

```
#include <gpib/ib.h>

volatile int ibcnt;
volatile long ibcntl;
```

Description

ibcnt and ibcntl are set after IO operations to the the the number of bytes sent or received. They are also set to the value of errno after EDVR or EFSO errors.

If you wish to avoid using a global variable, you may instead use **ThreadIbcnt()** or **ThreadIbcntl()** which return thread-specific values.

4.1.2 iberr

iberr — holds error code

Synopsis

```
#include <gpib/ib.h>

volatile int iberr;
```

Description

iberr is set whenever a function from the “traditional” or “multidevice” API fails with an error. The meaning of each possible value of iberr is summarized in the following table:

constant	value	meaning
EDVR	0	A system call has failed. ibcnt/ibcntl will be set to the value of errno.
ECIC	1	Your interface board needs to be controller-in-charge, but is not.

constant	value	meaning
ENOL	2	You have attempted to write data or command bytes, but there are no listeners currently addressed.
EADR	3	The interface board has failed to address itself properly before starting an io operation.
EARG	4	One or more arguments to the function call were invalid.
ESAC	5	The interface board needs to be system controller, but is not.
EABO	6	A read or write of data bytes has been aborted, possibly due to a timeout or reception of a device clear command.
ENEB	7	The GPIB interface board does not exist, its driver is not loaded, or it is not configured properly.
EDMA	8	Not used (DMA error), included for compatibility purposes.
EOIP	10	Function call can not proceed due to an asynchronous IO operation (ibrda(), ibwrta(), or ibcmda()) in progress.
ECAP	11	Incapable of executing function call, due the GPIB board lacking the capability, or the capability being disabled in software.
EFSO	12	File system error. ibcnt/ibcntl will be set to the value of errno.
EBUS	14	An attempt to write command bytes to the bus has timed out.
ESTB	15	One or more serial poll status bytes have been lost. This can occur due to too many status bytes accumulating (through automatic serial polling) without being read.
ESRQ	16	The serial poll request service line is stuck on. This can occur if a physical device on the bus requests service, but its GPIB address has not been opened (via ibdev() for example) by any process. Thus the automatic serial polling routines are unaware of the device's existence and will never serial poll it.
ETAB	20	This error can be returned by ibevent() , FindLstn(), or FindRQS(). See their descriptions for more information.

If you wish to avoid using a global variable, you may instead use **ThreadIberr()** which returns a thread-specific value.

4.1.3 ibsta

ibsta — holds status

Synopsis

```
#include <gplib/ib.h>

volatile int ibsta;
```

Description

ibsta is set whenever a function from the “traditional” or “multidevice” API is called. Each of the bits in ibsta has a different meaning, summarized in the following table:

bit	value (hexadecimal)	meaning	used for board/device
DCAS	0x1	DCAS is set when a board receives the device clear command (that is, the SDC or DCL command byte). It is cleared on the next “traditional” or “multidevice” function call following <code>ibwait()</code> (with DCAS set in the wait mask), or following a read or write (<code>ibrd()</code> , <code>ibwrt()</code> , <code>Receive()</code> , etc.). The DCAS and DTAS bits will only be set if the event queue is disabled. The event queue may be disabled with <code>ibconfig()</code> .	board
DTAS	0x2	DTAS is set when a board has received a device trigger command (that is, the GET command byte). It is cleared on the next “traditional” or “multidevice” function call following <code>ibwait()</code> (with DTAS in the wait mask). The DCAS and DTAS bits will only be set if the event queue is disabled. The event queue may be disabled with <code>ibconfig()</code> .	board
LACS	0x4	Board is currently addressed as a listener (IEEE listener state machine is in LACS or LADS).	board
TACS	0x8	Board is currently addressed as talker (IEEE talker state machine is in TACS or TADS).	board

bit	value (hexadecimal)	meaning	used for board/device
ATN	0x10	The ATN line is asserted.	board
CIC	0x20	Board is controller-in-charge, so it is able to set the ATN line.	board
REM	0x40	Board is in “remote” state.	board
LOK	0x80	Board is in “lockout” state.	board
CMPL	0x100	I/O operation is complete. Useful for determining when an asynchronous I/O operation (<code>ibrda()</code> , <code>ibwrta()</code> , etc) has completed.	board or device
EVENT	0x200	One or more clear, trigger, or interface clear events have been received, and are available in the event queue (see <code>ibevent()</code>). The EVENT bit will only be set if the event queue is enabled. The event queue may be enabled with <code>ibconfig()</code> .	board
SPOLL	0x400	If this bit is enabled (see <code>ibconfig()</code>), it is set when the board is serial polled. The SPOLL bit is cleared when the board requests service (see <code>ibrsrv()</code>) or you call <code>ibwait()</code> on the board with SPOLL in the wait mask.	board
RQS	0x800	RQS indicates that the device has requested service, and one or more status bytes are available for reading with <code>ibrsp()</code> . RQS will only be set if you have automatic serial polling enabled (see <code>ibconfig()</code>).	device
SRQI	0x1000	SRQI indicates that a device connected to the board is asserting the SRQ line. It is only set if the board is the controller-in-charge. If automatic serial polling is enabled (see <code>ibconfig()</code>), SRQI will generally be cleared, since when a device requests service it will be automatically polled and then unassert SRQ.	board

bit	value (hexadecimal)	meaning	used for board/device
END	0x2000	END is set if the last io operation ended with the EOI line asserted, and may be set on reception of the end-of-string character. The <code>IbcEndBitIsNormal</code> option of <code>ibconfig()</code> can be used to configure whether or not END should be set on reception of the eos character.	board or device
TIMO	0x4000	TIMO indicates that the last io operation or <code>ibwait()</code> timed out.	board or device
ERR	0x8000	ERR is set if the last “traditional” or “multidevice” function call failed. The global variable <code>iberr</code> will be set indicate the cause of the error.	board or device

If you wish to avoid using a global variable, you may instead use `ThreadIbsta()` which returns a thread-specific value.

4.2 “Traditional” API Functions

4.2.1 `ibask`

`ibask` — query configuration (board or device)

Synopsis

```
#include <gpib/ib.h>
```

```
int ibask(int ud, int option, int *result);
```

Description

Queries various configuration settings associated with the board or device descriptor `ud`. The `option` argument specifies the particular setting you wish to query. The result of the query is written to the location specified by `result`. To change the descriptor’s configuration, see `ibconfig()`.

option	value (hexadecimal)	result of query
IbaPAD	0x1	GPIB primary address
IbaSAD	0x2	GPIB secondary address (0 for none, 0x60 to 0x7e for secondary addresses 0 to 30)
IbaTMO	0x3	Timeout setting for io operations (a number from 0 to 17). See <code>ibmto()</code> .
IbaEOT	0x4	Nonzero if EOI is asserted with last byte on writes. See <code>ibeot()</code> .

option	value (hexadecimal)	result of query
IbaPPC	0x5	Parallel poll configuration. See ibppc() .
IbaREADDR	0x6	Useless, included for compatibility only.
IbaAUTOPOLL	0x7	Nonzero if automatic serial polling is enabled.
IbaCICPROT	0x8	Useless, included for compatibility only.
IbaSC	0xa	Nonzero if board is system controller. See ibrsc() .
IbaSRE	0xb	Nonzero if board automatically asserts REN line when it becomes the system controller. See ibsre() .
IbaEOSrd	0xc	Nonzero if termination of reads on reception of the end-of-string character is enabled. See ibeos() , in particular the REOS bit.
IbaEOSwrt	0xd	Nonzero if EOI is asserted whenever end-of-string character is sent. See ibeos() , in particular the XEOS bit.
IbaEOScmp	0xe	Nonzero if all 8 bits are used to match end-of-string character. Zero if only least significant 7 bits are used. See ibeos() , in particular the BIN bit.
IbaEOSchar	0xf	The end-of-string byte.
IbaPP2	0x10	Nonzero if in local parallel poll configure mode. Zero if in remote parallel poll configure mode.
IbaTIMING	0x11	Number indicating T1 delay. 1 for 2 microseconds, 2 for 500 nanoseconds, 3 for 350 nanoseconds. The values are declared in the header files as the constants T1_DELAY_2000ns, T1_DELAY_500ns, and T1_DELAY_350ns.
IbaReadAdjust	0x13	Nonzero if byte pairs are automatically swapped during reads.
IbaWriteAdjust	0x14	Nonzero if byte pairs are automatically swapped during writes.
IbaEventQueue	0x15	Nonzero if event queue is enabled.
IbaSPollBit	0x16	Nonzero if the use of the SPOLL bit in ibsta is enabled.
IbaSendLLO	0x17	Nonzero if devices connected to this board are automatically put into local lockout mode when brought online with ibfind() or ibdev() .
IbaSPollTime	0x18	Timeout for serial polls. The value of the result is between 0 and 17, and has the same meaning as in ibtmo() .
IbaPPollTime	0x19	Timeout for parallel polls. The value of the result is between 0 and 17, and has the same meaning as in ibtmo() .
IbaEndBitIsNormal	0x1a	Nonzero if END bit of ibsta is set on reception of end-of-string character or EOI. Zero if END bit is only set on EOI.

option	value (hexadecimal)	result of query
IbaUnAddr	0x1b	Nonzero if UNT (untalk) and UNL (unlisten) commands are automatically sent after a completed io operation using this descriptor.
IbaHSCableLength	0x1f	Useless, included only for compatibility.
IbaIst	0x20	Individual status bit, a.k.a. “ist”.
IbaRsv	0x21	The current status byte this board will use to respond to serial polls.
IbaBNA	0x200	Board index (minor number) of interface board which is the controller-in-charge of this device’s GPIB bus.
Iba7BitEOS	0x1000	Nonzero if board supports 7 bit EOS comparisons. See <code>ibeos()</code> , in particular the BIN bit. This is a Linux-GPIB extension.

Return value

The value of `ibsta` is returned.

4.2.2 `ibbna`

`ibbna` — change access board (device)

Synopsis

```
#include <gplib/ib.h>
```

```
int ibbna(int ud, const char *name);
```

Description

`ibbna()` changes the GPIB interface board used to access the device specified by `ud`. Subsequent device level calls using the descriptor `ud` will assume the device is connected to the interface board specified by `name`. If you wish to specify a device’s new access board by board index instead of name, you can use the `IbcBNA` option of `ibconfig()`.

The name of a board can be specified in the configuration file `gplib.conf`.

On success, `iberr` is set to the board index of the device’s old access board.

Return value

The value of `ibsta` is returned.

4.2.3 `ibcac`

`ibcac` — assert ATN (board)

Synopsis

```
#include <gpib/ib.h>
```

```
int ibcac(int ud, int synchronous);
```

Description

`ibcac()` causes the board specified by the board descriptor *ud* to become active controller by asserting the ATN line. The board must be controller-in-change in order to assert ATN. If *synchronous* is nonzero, then the board will wait for a data byte on the bus to complete its transfer before asserting ATN. If the synchronous attempt times out, or *synchronous* is zero, then ATN will be asserted immediately.

It is generally not necessary to call `ibcac()`. It is provided for advanced users who want direct, low-level access to the GPIB bus.

Return value

The value of **ibsta** is returned.

4.2.4 **ibclr**

`ibclr` — clear device (device)

Synopsis

```
#include <gpib/ib.h>
```

```
int ibclr(int ud);
```

Description

`ibclr()` sends the clear command to the device specified by *ud*.

Return value

The value of **ibsta** is returned.

4.2.5 **ibcmd**

`ibcmd` — write command bytes (board)

Synopsis

```
#include <gpib/ib.h>
```

```
int ibcmd(int ud, const void *commands, long num_bytes);
```

Description

`ibcmd()` writes the **command bytes** contained in the array `commands` to the bus. The number of bytes written from the array is specified by `num_bytes`. The `ud` argument is a board descriptor, and the board must be controller-in-charge. Most of the possible command bytes are declared as constants in the header files. In particular, the constants `GTL`, `SDC`, `PPConfig`, `GET`, `TCT`, `LLO`, `DCL`, `PPU`, `SPE`, `SPD`, `UNL`, `UNT`, and `PPD` are available. Additionally, the inline functions `MTA()`, `MLA()`, `MSA()`, and `PPE_byte()` are available for producing “my talk address”, “my listen address”, “my secondary address”, and “parallel poll enable” command bytes respectively.

It is generally not necessary to call `ibcmd()`. It is provided for advanced users who want direct, low-level access to the GPIB bus.

Return value

The value of **ibsta** is returned.

4.2.6 `ibcmda`

`ibcmda` — write command bytes asynchronously (board)

Synopsis

```
#include <gpib/ib.h>

int ibcmda(int ud, const void *commands, long num_bytes);
```

Description

`ibcmda()` is similar to **`ibcmd()`** except it operates asynchronously. `ibcmda()` does not wait for the sending of the command bytes to complete, but rather returns immediately.

While an asynchronous operation is in progress, most library functions will fail with an EOIP error. In order to successfully complete an asynchronous operation, you must call **`ibwait()`** with `CMPL` set in the wait mask, until the `CMPL` bit is set **ibsta**. Asynchronous operations may also be aborted with an **`ibstop()`** or **`ibonl()`** call.

After the asynchronous I/O has completed and the results resynchronized with the current thread, the Linux-GPIB extensions **`AsyncIbsta`**, **`AsyncIberr`**, **`AsyncIbcnt`** and **`AsyncIbcntl`** may be useful to more cleanly separate the results of the asynchronous I/O from the results of the `ibwait` or similar call used to resynchronize.

Return value

The value of **ibsta** is returned.

4.2.7 `ibconfig`

`ibconfig` — change configuration (board or device)

Synopsis

```
#include <gpib/ib.h>

int ibconfig(int ud, int option, int setting);
```

Description

Changes various configuration settings associated with the board or device descriptor `ud`. The `option` argument specifies the particular setting you wish to modify. The `setting` argument specifies the option’s new configuration. To query the descriptor’s configuration, see **`ibask()`**.

option	value (hexadecimal)	effect
IbcPAD	0x1	Sets GPIB primary address. Same as <code>ibpad()</code> .
IbcSAD	0x2	Sets GPIB secondary address. Same as <code>ibsad()</code> .
IbcTMO	0x3	Sets timeout for io operations. Same as <code>ibmto()</code> .
IbcEOT	0x4	If setting is nonzero, EOI is asserted with last byte on writes. Same as <code>ibeot()</code> .
IbcPPC	0x5	Sets parallel poll configuration. Same as <code>ibppc()</code> .
IbcREADDR	0x6	Useless, included for compatibility only.
IbcAUTOPOLL	0x7	If setting is nonzero then automatic serial polling is enabled.
IbcCICPROT	0x8	Useless, included for compatibility only.
IbcSC	0xa	If setting is nonzero, board becomes system controller. Same as <code>ibrsc()</code> .
IbcSRE	0xb	If setting is nonzero then board asserts REN line. Otherwise REN is unasserted. Same as <code>ibsre()</code> .
IbcEOSrd	0xc	If setting is nonzero then reads are terminated on reception of the end-of-string character. See <code>ibeos()</code> , in particular the REOS bit.
IbcEOSwrt	0xd	If setting is nonzero then EOI is asserted whenever the end-of-string character is sent. See <code>ibeos()</code> , in particular the XEOS bit.
IbcEOScmp	0xe	If setting is nonzero then all 8 bits are used to match the end-of-string character. Otherwise only the least significant 7 bits are used. See <code>ibeos()</code> , in particular the BIN bit.
IbcEOSchar	0xf	Sets the end-of-string byte. See <code>ibeos()</code> .
IbcPP2	0x10	If setting is nonzero then the board is put into local parallel poll configure mode (IEEE 488.1 PP2 subset), and will not change its parallel poll configuration in response to receiving “parallel poll enable” command bytes from the controller-in-charge. Instead, the parallel poll configuration is set locally by doing a board-level call of <code>ibppc()</code> . A zero value puts the board in remote parallel poll configure mode (IEEE 488.1 PP1 subset). IEEE 488.2 requires devices to support the remote PP1 subset and not the local PP2 subset. Some older hardware does not support local parallel poll configure mode.

option	value (hexadecimal)	effect
IbcTIMING	0x11	Sets the T1 delay. Use setting of 1 for 2 microseconds, 2 for 500 nanoseconds, or 3 for 350 nanoseconds. These values are declared in the header files as the constants T1_DELAY_2000ns, T1_DELAY_500ns, and T1_DELAY_350ns. A 2 microsecond T1 delay is safest, but will limit maximum transfer speeds to a few hundred kilobytes per second.
IbcReadAdjust	0x13	If setting is nonzero then byte pairs are automatically swapped during reads. Presently, this feature is unimplemented.
IbcWriteAdjust	0x14	If setting is nonzero then byte pairs are automatically swapped during writes. Presently, this feature is unimplemented.
IbcEventQueue	0x15	If setting is nonzero then the event queue is enabled. The event queue is disabled by default.
IbcSPollBit	0x16	If the setting is nonzero then the use of the SPOLL bit in ibsta is enabled.
IbcSendLLO	0x17	If the setting is nonzero then devices connected to this board are automatically put into local lockout mode when brought online with ibfind() or ibdev().
IbcSPollTime	0x18	Sets timeout for serial polls. The setting must be between 0 and 17, which correspond to the same time periods as in ibtmo() .
IbcPPollTime	0x19	Sets timeout for parallel polls. The setting must be between 0 and 17, which correspond to the same time periods as in ibtmo() .
IbcEndBitIsNormal	0x1a	If setting is nonzero then the END bit of ibsta is set on reception of the end-of-string character or EOI (default). Otherwise END bit is only set on EOI.
IbcUnAddr	0x1b	If setting is nonzero then UNT (untalk) and UNL (unlisten) commands are automatically sent after a completed io operation using this descriptor. This option is off by default.
IbcHSCableLength	0x1f	Useless, included only for compatibility.
IbcIst	0x20	Sets the individual status bit, a.k.a. “ist”. Same as ibist() .
IbcRsv	0x21	Sets the current status byte this board will use to respond to serial polls. Same as ibrsv() .

option	value (hexadecimal)	effect
IbcBNA	0x200	Changes the GPIB interface board used to access a device. The setting specifies the board index of the new access board. This configuration option is similar to <code>ibbna()</code> except the new board is specified by its board index instead of a name.

Return value

The value of `ibsta` is returned.

4.2.8 ibdev

`ibdev` — open a device (device)

Synopsis

```
#include <gplib/ib.h>
```

```
int ibdev(int board_index, int pad, int sad, int timeout, int send_eoi, int eos);
```

Description

`ibdev()` is used to obtain a device descriptor, which can then be used by other functions in the library. The argument `board_index` specifies which GPIB interface board the device is connected to. The `pad` and `sad` arguments specify the GPIB address of the device to be opened (see `ibpad()` and `ibsad()`). The timeout for io operations is specified by `timeout` (see `ibtmo()`). If `send_eoi` is nonzero, then the EOI line will be asserted with the last byte sent during writes (see `ibeot()`). Finally, the `eos` argument specifies the end-of-string character and whether or not its reception should terminate reads (see `ibeos()`).

Return value

If successful, returns a (non-negative) device descriptor. On failure, -1 is returned.

4.2.9 ibeos

`ibeos` — set end-of-string mode (board or device)

Synopsis

```
#include <gplib/ib.h>
```

```
int ibeos(int ud, int eosmode);
```

Description

`ibeos()` is used to set the end-of-string character and mode. The least significant 8 bits of `eosmode` specify the eos character. You may also bitwise-or one or more of the following bits to set the eos mode:

constant	value (hexadecimal)	meaning
REOS	0x400	Enable termination of reads when eos character is received.
XEOS	0x800	Assert the EOI line whenever the eos character is sent during writes.
BIN	0x1000	Match eos character using all 8 bits (instead of only looking at the 7 least significant bits).

Return value

The value of **ibsta** is returned.

4.2.10 ibeot

ibeot — assert EOI with last data byte (board or device)

Synopsis

```
#include <gplib/ib.h>
```

```
int ibeot(int ud, int send_eoi);
```

Description

If *send_eoi* is non-zero, then the EOI line will be asserted with the last byte sent by calls to **ibwrt()** and related functions.

Return value

The value of **ibsta** is returned.

4.2.11 ibevent

ibevent — get events from event queue (board)

Synopsis

```
#include <gplib/ib.h>
```

```
int ibevent(int ud, short *event);
```

Description

ibevent() is used to obtain the oldest event stored in the event queue of the board specified by the board descriptor *ud*. The **EVENT** bit of **ibsta** indicates that the event queue contains 1 or more events. An event may be a clear command, a trigger command, or reception of an interface clear. The type of event is stored in the location specified by *event* and may be set to any of the following values:

constant	value	description
EventNone	0	The board's event queue is empty
EventDevTrg	1	The board has received a trigger command from the controller-in-charge.
EventDevClr	2	The board has received a clear command from the controller-in-charge.
EventIFC	3	The board has received an interface clear from the system controller. Note, some models of GPIB interface board lack the ability to report interface clear events.

The event queue is disabled by default. It may be enabled by a call to `ibconfig()`. Each interface board has a single event queue which is shared across all processes and threads. So, only one process can retrieve any given event from the queue. Also, the queue is of finite size so events may be lost (`ibevent()` will return an error) if it is neglected too long.

Return value

The value of `ibsta` is returned.

4.2.12 `ibfind`

`ibfind` — open a board or device (board or device)

Synopsis

```
#include <gplib/ib.h>
```

```
int ibfind(const char *name);
```

Description

`ibfind()` returns a board or device descriptor based on the information found in the `configuration file`. It is not required to use this function, since device descriptors can be obtained with `ibdev()` and the “board index” (minor number in the configuration file) can be used directly as a board descriptor.

Return value

If successful, returns a (non-negative) board or device descriptor. On failure, -1 is returned.

4.2.13 `ibgts`

`ibgts` — release ATN (board)

Synopsis

```
#include <gplib/ib.h>
```

```
int ibgts(int ud, int shadow_handshake);
```

Description

`ibgts()` is the complement of `ibcac()`, and causes the board specified by the board descriptor `ud` to go to standby by releasing the ATN line. The board must be controller-in-change to change the state of the ATN line. If `shadow_handshake` is nonzero, then the board will handshake any data bytes it receives until it encounters an EOI or end-of-string character, or the ATN line is asserted again. The received data is discarded.

It is generally not necessary to call `ibgts()`. It is provided for advanced users who want direct, low-level access to the GPIB bus.

Return value

The value of `ibsta` is returned.

4.2.14 `ibist`

`ibist` — set individual status bit (board)

Synopsis

```
#include <gplib/ib.h>
```

```
int ibist(int ud, int ist);
```

Description

If `ist` is nonzero, then the individual status bit of the board specified by the board descriptor `ud` is set. If `ist` is zero then the individual status bit is cleared. The individual status bit is sent by the board in response to parallel polls.

On success, `iberr` is set to the previous `ist` value.

Return value

The value of `ibsta` is returned.

4.2.15 `iblines`

`iblines` — monitor bus lines (board)

Synopsis

```
#include <gplib/ib.h>
```

```
int iblines(int ud, short *line_status);
```

Description

`iblines()` is used to obtain the status of the control and handshaking **bus lines** of the bus. The board used to monitor the bus is specified by the `ud` argument, and the status of the various bus lines are written to the location specified by `line_status`.

Some older chips are not capable of reporting the status of the bus lines, so each line has two corresponding bits in `line_status`. One bit indicates if the board can monitor the line, and the other bit indicates the line's state. The meaning of the `line_status` bits are as follows:

constant	value	description
ValidDAV	0x1	The BusDAV bit is valid.
ValidNDAC	0x2	The BusNDAC bit is valid.
ValidNRFD	0x4	The BusNRFD bit is valid.
ValidIFC	0x8	The BusIFC bit is valid.
ValidREN	0x10	The BusREN bit is valid.
ValidSRQ	0x20	The BusSRQ bit is valid.
ValidATN	0x40	The BusATN bit is valid.
ValidEOI	0x80	The BusEOI bit is valid.
BusDAV	0x100	Set/cleared if the DAV line is asserted/unasserted.
BusNDAC	0x200	Set/cleared if the NDAC line is asserted/unasserted.
BusNRFD	0x400	Set/cleared if the NRFD line is asserted/unasserted.
BusIFC	0x800	Set/cleared if the IFC line is asserted/unasserted.
BusREN	0x1000	Set/cleared if the REN line is asserted/unasserted.
BusSRQ	0x2000	Set/cleared if the SRQ line is asserted/unasserted.
BusATN	0x4000	Set/cleared if the ATN line is asserted/unasserted.
BusEOI	0x8000	Set/cleared if the EOI line is asserted/unasserted.

Return value

The value of `ibsta` is returned.

4.2.16 `ibln`

`ibln` — check if listener is present (board or device)

Synopsis

```
#include <gplib/ib.h>
```

```
int ibln(int ud, int pad, int sad, short *found_listener);
```

Description

`ibln()` checks for the presence of a device, by attempting to address it as a listener. *ud* specifies the GPIB interface board which should check for listeners. If *ud* is a device descriptor, then the device's access board is used.

The GPIB address to check is specified by the *pad* and *sad* arguments. *pad* specifies the primary address, 0 through 30 are valid values. *sad* gives the secondary address, and may be a value from 0x60 through 0x7e (96 through 126), or one of the constants `NO_SAD` or `ALL_SAD`. `NO_SAD` indicates that no secondary addressing is to be used, and `ALL_SAD` indicates that all secondary addresses should be checked.

If the board finds a listener at the specified GPIB address(es), then the variable specified by the pointer *found_listener* is set to a nonzero value. If no listener is found, the variable is set to zero.

The board must be controller-in-charge to perform this function. Also, it must have the capability to monitor the NDAC bus line (see `iblines()`).

Return value

The value of `ibsta` is returned.

4.2.17 ibloc

`ibloc` — go to local mode (board or device)

Synopsis

```
#include <gpib/ib.h>
```

```
int ibloc(int ud);
```

Description

Causes the board or device specified by the descriptor `ud` to go to local mode. If `ud` is a board descriptor, and the board is in local lockout, then the function will fail.

Note, if the system controller is asserting the REN line, then devices on the bus will return to remote mode the next time they are addressed by the controller in charge.

Return value

The value of `ibsta` is returned.

4.2.18 ibonl

`ibonl` — close or reinitialize descriptor (board or device)

Synopsis

```
#include <gpib/ib.h>
```

```
int ibonl(int ud, int online);
```

Description

If the `online` is zero, then `ibonl()` frees the resources associated with the board or device descriptor `ud`. The descriptor cannot be used again after the `ibonl()` call.

If the `online` is nonzero, then all the settings associated with the descriptor (GPIB address, end-of-string mode, timeout, etc.) are reset to their “default” values. The “default” values are the settings the descriptor had when it was first obtained with `ibdev()` or `ibfind()`.

Return value

The value of `ibsta` is returned.

4.2.19 ibpad

`ibpad` — set primary GPIB address (board or device)

Synopsis

```
#include <gpib/ib.h>
```

```
int ibpad(int ud, int pad);
```

Description

ibpad() sets the GPIB primary address to *pad* for the device or board specified by the descriptor *ud*. If *ud* is a device descriptor, then the setting is local to the descriptor (it does not affect the behaviour of calls using other descriptors, even if they refer to the same physical device). If *ud* is a board descriptor, then the board's primary address is changed immediately, which is a global change affecting anything (even other processes) using the board. Valid GPIB primary addresses are in the range from 0 to 30.

Return value

The value of **ibsta** is returned.

4.2.20 **ibpct**

ibpct — pass control (board)

Synopsis

```
#include <gpib/ib.h>
```

```
int ibpct(int ud);
```

Description

ibpct() passes control to the device specified by the device descriptor *ud*. The device becomes the new controller-in-charge.

Return value

The value of **ibsta** is returned.

4.2.21 **ibppc**

ibppc — parallel poll configure (board or device)

Synopsis

```
#include <gpib/ib.h>
```

```
int ibppc(int ud, int configuration);
```

Description

Configures the parallel poll response of the device or board specified by *ud*. The *configuration* should either be set to the “PPD” constant to disable parallel poll responses, or set to the return value of the **PPE_byte()** inline function to enable and configure the parallel poll response.

If *ud* is a device descriptor then the device will be remotely configured by the controller.

If *ud* is a board descriptor then the board will be locally configured. Note, in order to do a local parallel poll configuration **IbcPP2** must be set using **ibconfig()**. IEEE 488.2 prohibits local parallel poll configuration (IEEE 488.1 PP2 subset), requiring support for remote parallel poll configuration (IEEE 488.1 PP1 subset) instead.

After configuring the parallel poll response of devices on a bus, you may use **ibrpp()** to parallel poll the devices.

Return value

The value of `ibsta` is returned.

4.2.22 `ibrd`

`ibrd` — read data bytes (board or device)

Synopsis

```
#include <gpib/ib.h>
```

```
int ibrd(int ud, void *buffer, long num_bytes);
```

Description

`ibrd()` is used to read data bytes from a device or board. The argument `ud` can be either a device or board descriptor. Up to `num_bytes` bytes are read into the user-supplied array `buffer`. The read may be terminated by a timeout occurring (see `ibtmo()`), the talker asserting the EOI line, the board receiving the end-of-string character (see `ibeos()`), receiving a device clear command, or receiving an interface clear.

If `ud` is a device descriptor, then the library automatically handles addressing the device as talker and the interface board as listener before performing the read.

If `ud` is a board descriptor, no addressing is performed and the board must be addressed as a listener by the controller-in-charge.

After the `ibrd()` call, `ibcnt` and `ibcntl` are set to the number of bytes read.

Return value

The value of `ibsta` is returned.

4.2.23 `ibrda`

`ibrda` — read data bytes asynchronously (board or device)

Synopsis

```
#include <gpib/ib.h>
```

```
int ibrda(int ud, void *buffer, long num_bytes);
```

Description

`ibrda()` is similar to `ibrd()` except it operates asynchronously. `ibrda()` does not wait for the reception of the data bytes to complete, but rather returns immediately.

While an asynchronous operation is in progress, most library functions will fail with an EOIP error. In order to successfully complete an asynchronous operation and resynchronize its results with the current thread, you must call `ibwait()` with CMPL set in the wait mask, until the CMPL bit is set `ibsta`. Asynchronous operations may also be completed by a call to `ibstop()` or `ibonl()` call. Note, `ibwait()` will only complete the asynchronous operation if you explicitly set the CMPL bit in the wait mask parameter of `ibwait()`.

After the asynchronous I/O has completed and the results resynchronized with the current thread, the Linux-GPIB extensions `AsyncIbsta`, `AsyncIberr`, `AsyncIbcnt` and `AsyncIbcntl` may be useful to more cleanly separate the results of the asynchronous I/O from the results of the `ibwait` or similar call used to resynchronize.

Return value

The value of `ibsta` is returned.

4.2.24 `ibrdf`

`ibrdf` — read data bytes to file (board or device)

Synopsis

```
#include <gpib/ib.h>
```

```
int ibrdf(int ud, const char *file_path);
```

Description

`ibrdf()` is similar to `ibrd()` except that the data bytes read are stored in a file instead of an array in memory. *file_path* specifies the save file. If the file already exists, the data will be appended onto the end of the file.

Return value

The value of `ibsta` is returned.

4.2.25 `ibrpp`

`ibrpp` — perform a parallel poll (board or device)

Synopsis

```
#include <gpib/ib.h>
```

```
int ibrpp(int ud, char *ppoll_result);
```

Description

`ibrpp()` causes the interface board to perform a parallel poll, and stores the resulting parallel poll byte in the location specified by *ppoll_result*. Bits 0 to 7 of the parallel poll byte correspond to the dio lines 1 to 8, with a 1 indicating the corresponding dio line is asserted. The devices on the bus you wish to poll should be configured beforehand with `ibppc()`. The board which performs the parallel poll must be controller-in-charge, and is specified by the descriptor *ud*. If *ud* is a device descriptor instead of a board descriptor, the device's access board performs the parallel poll.

Return value

The value of `ibsta` is returned.

4.2.26 `ibrsc`

`ibrsc` — request system control (board)

Synopsis

```
#include <gpib/ib.h>
```

```
int ibrsc(int ud, int request_control);
```

Description

If *request_control* is nonzero, then the board specified by the board descriptor *ud* is made system controller. If *request_control* is zero, then the board releases system control.

The system controller has the ability to assert the REN and IFC lines, and is typically also the controller-in-charge. A GPIB bus may not have more than one system controller.

Return value

The value of **ibsta** is returned.

4.2.27 ibrsp

ibrsp — read status byte / serial poll (device)

Synopsis

```
#include <gpib/ib.h>
```

```
int ibrsp(int ud, char *result);
```

Description

ibrsp() obtains the status byte from the device specified by *ud*. The status byte is stored in the location specified by *result*.

If automatic serial polling is enabled on the board controlling the device, the status byte is automatically read and queued whenever the device requests service. If the status byte queue is not empty **ibrsp()** obtains the status byte information from the queue. If the queue is empty the status byte is obtained by serial polling the device. Automatic serial polling is controlled with **ibconfig()**. The contents of the status byte returned in *result* are device specific. Refer to the device manufacturer's documentation for details. For devices conforming to the IEEE488.1 or 2 specification the bits defined in the table below are available if enabled in the device's Status Byte Enable register.

constant	value	description
IbStbRQS	0x40	The request service bit is set when device asserts RQS. It is cleared by serial polling the device. Supported by devices conforming to IEEE 488.1 or IEEE 488.2.
IbStbESB	0x20	The event-status bit is set when there are one or more bits set in the device's Standard Event Status Register. It is cleared by reading the Standard Event Status Register. For devices conforming to IEEE 488.2 only.

constant	value	description
IbStbMAV	0x10	The message available bit indicates whether or not the device's data output queue is empty. Whenever the device has data available, this bit will be set. It is cleared when the output queue is empty. The queue is emptied by reading data from the device with <code>ibrd()</code> for example. For devices conforming to IEEE 488.2 only.

Return value

The value of `ibsta` is returned.

4.2.28 ibrsv

`ibrsv` — request service (board)

Synopsis

```
#include <gpiib/ib.h>

int ibrsv(int ud, int status_byte);
```

Description

The serial poll response byte of the board specified by the board descriptor `ud` is set to `status_byte`. If the request service bit (0x40 hexadecimal) in `status_byte` is set, then the board will also request service by asserting the RQS line.

Return value

The value of `ibsta` is returned.

4.2.29 ibsad

`ibsad` — set secondary GPIB address (board or device)

Synopsis

```
#include <gpiib/ib.h>

int ibsad(int ud, int sad);
```

Description

`ibsad()` sets the GPIB secondary address of the device or board specified by the descriptor `ud`. If `ud` is a device descriptor, then the setting is local to the descriptor (it does not affect the behaviour of calls using other descriptors, even if they refer to the same physical device). If `ud` is a board descriptor, then the board's secondary address is changed immediately, which is a global change affecting anything (even other processes) using the board.

This library follows NI's unfortunate convention of adding 0x60 hexadecimal (96 decimal) to secondary addresses. That is, if you wish to set the secondary address to 3, you should set `sad` to 0x63. Setting `sad` to 0 disables the use of secondary addressing. Valid GPIB secondary addresses are in the range from 0 to 30 (which correspond to `sad` values of 0x60 to 0x7e).

Return value

The value of `ibsta` is returned.

4.2.30 ibsic

`ibsic` — perform interface clear (board)

Synopsis

```
#include <gpib/ib.h>
```

```
int ibsic(int ud);
```

Description

`ibsic()` resets the GPIB bus by asserting the “interface clear” (IFC) bus line for a duration of at least 100 microseconds. The board specified by `ud` must be the system controller in order to assert IFC. The interface clear causes all devices to untalk and unlisten, puts them into serial poll disabled state (don’t worry, you will still be able to conduct serial polls), and the board becomes controller-in-charge.

Return value

The value of `ibsta` is returned.

4.2.31 ibspb

`ibspb` — obtain length of serial poll bytes queue (device)

Synopsis

```
#include <gpib/ib.h>
```

```
int ibspb(int ud, short *result);
```

Description

`ibspb()` obtains the number of serial poll bytes queued for the device specified by `ud`. The number of queued serial poll bytes is stored in the location specified by `result`.

If automatic serial polling is enabled on the board controlling the device, the status byte is automatically read and queued whenever the device requests service. Automatic serial polling is controlled with `ibconfig()`.

The queued status bytes are read with `ibrsp()`.

Return value

The value of `ibsta` is returned.

4.2.32 ibsre

`ibsre` — set remote enable (board)

Synopsis

```
#include <gpib/ib.h>
```

```
int ibsre(int ud, int enable);
```

Description

If *enable* is nonzero, then the board specified by the board descriptor *ud* asserts the REN line. If *enable* is zero, the REN line is unasserted. The board must be the system controller.

Return value

The value of **ibsta** is returned.

4.2.33 ibstop

ibstop — abort asynchronous i/o operation (board or device)

Synopsis

```
#include <gpib/ib.h>
```

```
int ibstop(int ud);
```

Description

ibstop() aborts an asynchronous i/o operation (for example, one started with **ibcmda**(), **ibrda**(), or **ibwrta**()).

The return value of **ibstop**() is counter-intuitive. On successfully aborting an asynchronous operation, the ERR bit is set in **ibsta**, and **iberr** is set to EABO. If the ERR bit is not set in **ibsta**, then there was no asynchronous i/o operation in progress. If the function failed, the ERR bit will be set and **iberr** will be set to some value other than EABO.

Return value

The value of **ibsta** is returned.

4.2.34 ibtmo

ibtmo — adjust io timeout (board or device)

Synopsis

```
#include <gpib/ib.h>
```

```
int ibtmo(int ud, int timeout);
```

Description

ibtmo() sets the timeout for IO operations and **ibwait** calls performed using the board or device descriptor *ud*. The actual amount of time before a timeout occurs may be greater than the period specified, but never less. *timeout* is specified by using one of the following constants:

constant	value	timeout
TNONE	0	Never timeout.
T10us	1	10 microseconds
T30us	2	30 microseconds
T100us	3	100 microseconds
T300us	4	300 microseconds
T1ms	5	1 millisecond
T3ms	6	3 milliseconds
T10ms	7	10 milliseconds
T30ms	8	30 milliseconds
T100ms	9	100 milliseconds
T300ms	10	300 milliseconds
T1s	11	1 second
T3s	12	3 seconds
T10s	13	10 seconds
T30s	14	30 seconds
T100s	15	100 seconds
T300s	16	300 seconds
T1000s	17	1000 seconds

Return value

The value of **ibsta** is returned.

4.2.35 ibtrg

ibtrg — trigger device (device)

Synopsis

```
#include <gpib/ib.h>
```

```
int ibtrg(int ud);
```

Description

ibtrg() sends a GET (group execute trigger) **command byte** to the device specified by the device descriptor *ud*.

Return value

The value of **ibsta** is returned.

4.2.36 ibvers

ibvers — Obtain the current linux gpib version.

Synopsis

```
#include <gpib/ib.h>
```

```
void ibvers(char ** version);
```

Description

ibvers() will return the current version string in *version*.

4.2.37 ibwait

ibwait — wait for event (board or device)

Synopsis

```
#include <gplib/ib.h>
```

```
int ibwait(int ud, int status_mask);
```

Description

ibwait() will sleep until one of the conditions specified in *status_mask* is true. The meaning of the bits in *status_mask* are the same as the bits of the **ibsta** status variable.

If *status_mask* is zero, then ibwait() will return immediately. This is useful if you simply wish to get an updated **ibsta**.

When calling ibwait() on a device, only the following condition bits in the *status_mask* are valid: TIMO, END, CMPL, and RQS. For the RQS bit to be set in the returned **ibsta** automatic serial polling must be enabled for the board controlling the device, see **ibconfig()**. The RQS condition is cleared by serial polling the device, see **ibrsp()**.

If you wish to resynchronize and obtain the results from an asynchronous I/O operation, you must wait on CMPL by setting its bit in the *status_mask* parameter. Then if ibwait returns with CMPL set, it will have updated **iberr**, **ibcnt**, and the **ERR** bit of **ibsta** with the most recent asynchronous I/O results.

If TIMO is set in the *status_mask* parameter, then ibwait will timeout after the time period set by **ibtmo** and set TIMO in **ibsta**.

Return value

The value of **ibsta** is returned.

4.2.38 ibwrt

ibwrt — write data bytes (board or device)

Synopsis

```
#include <gplib/ib.h>
```

```
int ibwrt(int ud, const void *data, long num_bytes);
```

Description

ibwrt() is used to write data bytes to a device or board. The argument *ud* can be either a device or board descriptor. *num_bytes* specifies how many bytes are written from the user-supplied array *data*. EOI may be asserted with the last byte sent or when the end-of-string character is sent (see **ibeos()** and **ibeot()**). The write operation may be interrupted by a timeout (see **ibtmo()**), the board receiving a device clear command, or receiving an interface clear.

If *ud* is a device descriptor, then the library automatically handles addressing the device as listener and the interface board as talker, before sending the data bytes onto the bus.

If *ud* is a board descriptor, the board simply writes the data onto the bus. The controller-in-charge must address the board as talker.

After the ibwrt() call, **ibcnt** and **ibcntl** are set to the number of bytes written.

Return value

The value of `ibsta` is returned.

4.2.39 ibwrta

`ibwrta` — write data bytes asynchronously (board or device)

Synopsis

```
#include <gpib/ib.h>
```

```
int ibwrta(int ud, const void *buffer, long num_bytes);
```

Description

`ibwrta()` is similar to `ibwrt()` except it operates asynchronously. `ibwrta()` does not wait for the sending of the data bytes to complete, but rather returns immediately.

While an asynchronous operation is in progress, most library functions will fail with an EOIP error. In order to successfully complete an asynchronous operation, you must call `ibwait()` with CMPL set in the wait mask, until the CMPL bit is set `ibsta`. Asynchronous operations may also be aborted with an `ibstop()` or `ibonl()` call.

After the asynchronous I/O has completed and the results resynchronized with the current thread, the Linux-GPIB extensions `AsyncIbsta`, `AsyncIberr`, `AsyncIbcnt` and `AsyncIbcntl` may be useful to more cleanly separate the results of the asynchronous I/O from the results of the `ibwait` or similar call used to resynchronize.

Return value

The value of `ibsta` is returned.

4.2.40 ibwrtf

`ibwrtf` — write data bytes from file (board or device)

Synopsis

```
#include <gpib/ib.h>
```

```
int ibwrtf(int ud, const char *file_path);
```

Description

`ibwrtf()` is similar to `ibwrt()` except that the data to be written is taken from a file instead of an array in memory. `file_path` specifies the file, which is written byte for byte onto the bus.

Return value

The value of `ibsta` is returned.

4.3 “Multidevice” API Functions

The “Multidevice” API functions provide similar functionality to the “Traditional” API functions. However, some of the “multi-device” functions can be performed on multiple devices simultaneously. For example, **SendList()** can be used to write a message to multiple devices. Such functions take an array of `Addr4882_t` as an argument. The end of the array is specified by setting the last element to the constant `NOADDR`.

4.3.1 AllSPoll

AllSPoll — serial poll multiple devices

Synopsis

```
#include <gpib/ib.h>
```

```
void AllSPoll(int board_desc, Addr4882_t *addressList, short *resultList);  
void AllSpoll(int board_desc, const Addr4882_t *addressList, short *resultList);
```

Description

AllSPoll() causes the interface board specified by *board_desc* to serial poll all the GPIB addresses specified in the *addressList* array. The results of the serial polls are stored into *resultList*. If you only wish to serial poll a single device, **ReadStatusByte()** or **ibrsp()** may be more convenient.

This function may also be invoked with the alternate capitalization “AllSpoll” for compatibility with NI’s library.

4.3.2 DevClear

DevClear — clear a device

Synopsis

```
#include <gpib/ib.h>
```

```
void DevClear(int board_desc, Addr4882_t address);
```

Description

DevClear() causes the interface board specified by *board_desc* to send the clear command to the GPIB addresses specified by *address*. The results of the serial polls are stored into *resultList*. If you wish to clear multiple devices simultaneously, use **DevClearList()**

4.3.3 DevClearList

DevClearList — clear multiple devices

Synopsis

```
#include <gpib/ib.h>
```

```
void DevClearList(int board_desc, const Addr4882_t addressList[]);
```

Description

DevClear() causes the interface board specified by *board_desc* to send the clear command simultaneously to all the GPIB addresses specified by the *addressList* array. If *addressList* is empty or NULL, then the clear command is sent to all devices on the bus. If you only wish to clear a single device, **DevClear()** or **ibclr()** may be slightly more convenient.

4.3.4 EnableLocal

EnableLocal — put devices into local mode.

Synopsis

```
#include <gpib/ib.h>
```

```
void EnableLocal(int board_desc, const Addr4882_t addressList[]);
```

Description

EnableLocal() addresses all of the devices in the *addressList* array as listeners then sends the GTL (go to local) command byte, causing them to enter local mode. This requires that the board is the controller-in-charge. Note that while the REN (remote enable) bus line is asserted, the devices will return to remote mode the next time they are addressed.

If *addressList* is empty or NULL, then the REN line is unasserted and all devices enter local mode. The board must be system controller to change the state of the REN line.

4.3.5 EnableRemote

EnableRemote — put devices into remote mode.

Synopsis

```
#include <gpib/ib.h>
```

```
void EnableRemote(int board_desc, const Addr4882_t addressList[]);
```

Description

EnableRemote() asserts the REN (remote enable) line, and addresses all of the devices in the *addressList* array as listeners (causing them to enter remote mode). The board must be system controller.

4.3.6 FindLstn

FindLstn — find devices

Synopsis

```
#include <gpib/ib.h>
```

```
void FindLstn(int board_desc, const Addr4882_t padList[], Addr4882_t resultList[], int maxNumResults);
```

Description

FindLstn() will check the primary addresses in the *padList* array for devices. The GPIB addresses of all devices found will be stored in the *resultList* array, and *ibcnt* will be set to the number of devices found. The *maxNumResults* parameter limits the maximum number of results that will be returned, and is usually set to the number of elements in the *resultList* array. If more than *maxNumResults* devices are found, an ETAB error is returned in *iberr*. The *padList* should consist of primary addresses only, with no secondary addresses (all possible secondary addresses will be checked as necessary).

Your GPIB board must have the capability to monitor the NDAC bus line in order to use this function (see *iblines*).

4.3.7 FindRQS

FindRQS — find device requesting service and read its status byte

Synopsis

```
#include <gplib/ib.h>
```

```
void FindRQS(int board_desc, const Addr4882_t addressList[], short *status);
```

Description

FindRQS will serial poll the GPIB addresses specified in the *addressList* array until it finds a device requesting service. The status byte of the device requesting service is stored in the location specified by *status*. The *addressList* array index of the device requesting service is returned in *ibcnt*. If no device requesting service is found, an ETAB error is returned in *iberr*.

4.3.8 PassControl

PassControl — make device controller-in-charge

Synopsis

```
#include <gplib/ib.h>
```

```
void PassControl(int board_desc, const Addr4882_t address);
```

Description

PassControl() causes the board specified by *board_desc* to pass control to the device specified by *address*. On success, the device becomes the new controller-in-charge.

4.3.9 PPoll

PPoll — parallel poll devices

Synopsis

```
#include <gplib/ib.h>
```

```
void PPoll(int board_desc, short *result);
```

Description

PPoll() is similar to the “traditional” API function `ibrpp()`. It causes the interface board to perform a parallel poll, and stores the parallel poll byte in the location specified by `result`. Bits 0 to 7 of the parallel poll byte correspond to the dio lines 1 to 8, with a 1 indicating the corresponding dio line is asserted. The devices on the bus you wish to poll should be configured beforehand with `PPollConfig()`. The board must be controller-in-charge to perform a parallel poll.

4.3.10 PPollConfig

PPollConfig — configure a device’s parallel poll response

Synopsis

```
#include <gpib/ib.h>
```

```
void PPollConfig(int board_desc, Addr4882_t address, int dio_line, int line_sense);
```

Description

PPollConfig() configures the device specified by `address` to respond to parallel polls. The `dio_line` (valid values are 1 through 8) specifies which dio line the device being configured should use to send back its parallel poll response. The `line_sense` argument specifies the polarity of the response. If `line_sense` is nonzero, then the specified dio line will be asserted to indicate that the “individual status bit” (or “ist”) is 1. If `sense` is zero, then the specified dio line will be asserted when ist is zero.

4.3.11 PPollUnconfig

PPollUnconfig — disable devices’ parallel poll response

Synopsis

```
#include <gpib/ib.h>
```

```
void PPollUnconfig(int board_desc, const Addr4882_t addressList[]);
```

Description

PPollUnconfig() configures the devices specified by `addressList` to ignore parallel polls.

4.3.12 RcvRespMsg

RcvRespMsg — read data

Synopsis

```
#include <gpib/ib.h>
```

```
void RcvRespMsg(int board_desc, void *buffer, long count, int termination);
```

Description

RcvRespMsg() reads data from the bus. A device must have already been addressed as talker (and the board as listener) before calling this function. Addressing may be accomplished with the **ReceiveSetup()** function.

Up to *count* bytes are read into the array specified by *buffer*. The *termination* argument specifies the 8-bit end-of-string character (which must be a value from 0 to 255) whose reception will terminate a read. *termination* can also be set to the “STOPend” constant, in which case no end-of-string character will be used. Assertion of the EOI line will always end a read.

You may find it simpler to use the slightly higher level function **Receive()**, since it does not require addressing and reading of data to be performed separately.

4.3.13 ReadStatusByte

ReadStatusByte — serial poll a device

Synopsis

```
#include <gplib/ib.h>
```

```
void ReadStatusByte(int board_desc, Addr4882_t address, short *result);
```

Description

ReadStatusByte() causes the board specified by the board descriptor *board_desc* to serial poll the GPIB address specified by *address*. The status byte is stored at the location specified by the *result* pointer. If you wish to serial poll multiple devices, it may be slightly more efficient to use **AllSPoll()**. Serial polls may also be conducted with the “traditional API” function **ibrsp()**.

4.3.14 Receive

Receive — perform receive addressing and read data

Synopsis

```
#include <gplib/ib.h>
```

```
void Receive(int board_desc, Addr4882_t address, void *buffer, long count, int termination);
```

Description

Receive() performs the necessary addressing, then reads data from the device specified by *address*. It is equivalent to a **ReceiveSetup()** call followed by a **RcvRespMsg()** call.

4.3.15 ReceiveSetup

ReceiveSetup — perform receive addressing

Synopsis

```
#include <gplib/ib.h>
```

```
void ReceiveSetup(int board_desc, Addr4882_t address);
```

Description

ReceiveSetup() addresses the device specified by *address* as talker, and addresses the interface board as listener. A subsequent **RcvRespMsg()** call will read data from the device.

You may find it simpler to use the slightly higher level function **Receive()**, since it does not require addressing and reading of data to be performed separately.

4.3.16 ResetSys

ResetSys — reset system

Synopsis

```
#include <gpib/ib.h>
```

```
void ResetSys(int board_desc, const Addr4882_t addressList[]);
```

Description

ResetSys() has the following effects:

- The remote enable bus line is asserted.
- An interface clear is performed (the interface clear bus line is asserted for at least 100 microseconds).
- The device clear command is sent to all the devices on the bus.
- The *RST message is sent to every device specified in the *addressList*.

4.3.17 Send

Send — perform send addressing and write data

Synopsis

```
#include <gpib/ib.h>
```

```
void Send(int board_desc, Addr4882_t address, const void *data, long count, int eot_mode);
```

Description

Send() addresses the device specified by *address* as listener, then writes data onto the bus. It is equivalent to a **SendList()** except it only uses a single GPIB address to specify the listener instead of allowing an array of listeners.

4.3.18 SendCmds

SendCmds — write command bytes onto bus

Synopsis

```
#include <gpib/ib.h>
```

```
void SendCmds(int board_desc, const void *cmds, long count);
```

Description

SendCmds() writes *count* **command byte** onto the the GPIB bus from the array *cmds*.

It is generally not necessary to call SendCmds(). It is provided for advanced users who want direct, low-level access to the GPIB bus.

4.3.19 SendDataBytes

SendDataBytes — write data

Synopsis

```
#include <gpib/ib.h>
```

```
void SendDataBytes(int board_desc, const void *data, long count, int eot_mode);
```

Description

SendDataBytes() writes data to the bus. One or more devices must have already been addressed as listener (and the board as talker) before calling this function. Addressing may be accomplished with the **SendSetup()** function.

count bytes are written from the array specified by *data*. The *eot_mode* argument specifies how the message should be terminated, and may be any of the following values:

constant	value	description
NULLend	0	Do not assert EOI or add a newline at the end of the write.
DABend	1	Assert EOI with the last byte of the write.
NLend	2	Append a newline, and assert EOI with the newline at the end of the write.

You may find it simpler to use the slightly higher level functions **Send()** or **SendList()**, since they does not require addressing and writing of data to be performed separately.

4.3.20 SendIFC

SendIFC — perform interface clear

Synopsis

```
#include <gpib/ib.h>
```

```
void SendIFC(int board_desc);
```

Description

SendIFC() resets the GPIB bus by asserting the “interface clear” (IFC) bus line for a duration of at least 100 microseconds. The board specified by *board_desc* must be the system controller in order to assert IFC. The interface clear causes all devices to untalk and unlisten, puts them into serial poll disabled state (don’t worry, you will still be able to conduct serial polls), and the board becomes controller-in-charge.

4.3.21 SendList

SendList — write data to multiple devices

Synopsis

```
#include <gpib/ib.h>
```

```
void SendList(int board_desc, const Addr4882_t addressList[], const void *data, long count, int eot_mode);
```

Description

SendList() addresses the devices in *addressList* as listeners, then writes the contents of the array *data* to them. It is equivalent to a **SendSetup()** call followed by a **SendDataBytes()** call.

4.3.22 SendLLO

SendLLO — put devices into local lockout mode

Synopsis

```
#include <gpib/ib.h>
```

```
void SendLLO(int board_desc);
```

Description

SendLLO() asserts the “remote enable” bus line, then sends the LLO **command byte**. Any devices currently addressed as listener will be put into RWLS (remote with lockout state), and all other devices will enter LWLS (local with lockout state). Local lockout means the remote/local mode of devices cannot be changed though the devices’ front-panel controls. Unasserting the REN line should bring the devices out of lockout state.

The **SetRWLS()** performs a similar function, except it lets you specify which devices you wish to address as listener before sending the LLO command.

4.3.23 SendSetup

SendSetup — perform send addressing

Synopsis

```
#include <gpib/ib.h>
```

```
void SendSetup(int board_desc, const Addr4882_t addressList[]);
```

Description

SendSetup() addresses the devices in *addressList* as listeners, and addresses the interface board as talker. A subsequent **SendDataBytes()** call will write data to the devices.

You may find it simpler to use the slightly higher level functions **Send()** or **SendList()**, since they does not require addressing and writing of data to be performed separately.

4.3.24 SetRWLS

SetRWLS — put devices into remote with lockout state

Synopsis

```
#include <gpib/ib.h>
```

```
void SetRWLS(int board_desc, const Addr4882_t addressList[]);
```

Description

SetRWLS() asserts the “remote enable” bus line, addresses the devices in the *addressList* array as listeners, then sends the LLO **command byte**. The devices addressed as listener will be put into RWLS (remote with lockout state), and all other devices will enter LWLS (local with lockout state). Local lockout means the remote/local mode of devices cannot be changed though the devices’ front-panel controls. Unasserting the REN line should bring the devices out of the lockout state.

4.3.25 TestSRQ

TestSRQ — query state of SRQ bus line

Synopsis

```
#include <gpib/ib.h>
```

```
void TestSRQ(int board_desc, short *result);
```

Description

TestSRQ() checks the state of the SRQ **bus line** and writes its state to the location specified by *result*. A 1 indicates the SRQ line is asserted, and a 0 indicates the line is not asserted.

Some boards lack the capability to report the status of the SRQ line. In such a case, an ECAP error is returned in **iberr**.

4.3.26 TestSys

TestSys — perform self-test queries on devices

Synopsis

```
#include <gpib/ib.h>
```

```
void TestSys(int board_desc, const Addr4882_t addressList[], short results[]);
```

Description

TestSys() sends the “*TST?” message to all the devices in the *addressList* array, then reads their responses into the *results* array. This will cause devices that conform to the IEEE 488.2 standard to perform a self-test and respond with a zero on success. A non-zero response indicates an error during the self-test.

The number of devices which responded with nonzero values from their self-tests is returned in **ibcnt** and **ibcntl**. If a device fails to respond to the *TST? query, an error will be flagged in **ibsta** (this is different than NI’s documented behaviour which is broken).

4.3.27 Trigger

Trigger — trigger a device

Synopsis

```
#include <gpib/ib.h>
```

```
void Trigger(int board_desc, Addr4882_t address);
```

Description

Trigger() is equivalent to a **TriggerList()** call with a single address.

4.3.28 TriggerList

Trigger — trigger multiple devices

Synopsis

```
#include <gpib/ib.h>
```

```
void TriggerList(int board_desc, Addr4882_t addressList[]);
```

Description

TriggerList() sends a GET (group execute trigger) **command byte** to all the devices specified in the *addressList* array. If no addresses are specified in *addressList* then the GET command byte is sent without performing any addressing.

4.3.29 WaitSRQ

WaitSRQ — sleep until the SRQ bus line is asserted

Synopsis

```
#include <gpib/ib.h>
```

```
void WaitSRQ(int board_desc, short *result);
```

Description

WaitSRQ() sleeps until either the SRQ **bus line** is asserted, or a timeout (see **ibtmo()**) occurs. A “1” will be written to the location specified by *result* if SRQ was asserted, and a “0” will be written if the function timed out.

4.4 Utility Functions

4.4.1 AsyncIbcnt and AsyncIbcntI

AsyncIbcnt and AsyncIbcntI — ibcnt and ibcntI values for last asynchronous I/O operation

Synopsis

```
#include <gpib/ib.h>
```

```
int AsyncIbcnt(void);  
long AsyncIbcntl(void);
```

Description

AsyncIbcnt() and AsyncIbcntl() return thread-local counts related to the global variables **ibcnt** and **ibcntl**. Their values correspond to the result of the last asynchronous I/O operation resynchronized to the current thread by an **ibwait** or **ibstop** call. These functions only reflect the result of the asynchronous I/O operation itself and not, for example, the **ibwait** which resynchronized the asynchronous result to the current thread. Thus the result from AsyncIbcnt() is easier to interpret than ThreadIbcnt(), since it is unambiguous whether the value is associated with the asynchronous I/O result, or with the function call used to resynchronize (**ibwait** or **ibstop**).

These functions are Linux-GPIB extensions.

Return value

A value related to **ibcnt** or **ibcntl** corresponding to the last asynchronous I/O operation resynchronized to the current thread is returned.

4.4.2 AsyncIberr

AsyncIberr — **iberr** value for last asynchronous I/O operation

Synopsis

```
#include <gpib/ib.h>
```

```
int AsyncIberr(void);
```

Description

AsyncIberr() returns a thread-local error number related to the global variable **iberr**. Its value corresponds to the result of the last asynchronous I/O operation resynchronized to the current thread by an **ibwait** or **ibstop** call. This function only reflects the result of the asynchronous I/O operation itself and not, for example, the **ibwait** which resynchronized the asynchronous result to the current thread. Thus the result from AsyncIberr() is easier to interpret than ThreadIberr(), since it is unambiguous whether the value is associated with the asynchronous I/O result, or with the function call used to resynchronize (**ibwait** or **ibstop**).

This function is a Linux-GPIB extension.

Return value

A value related to **iberr** corresponding to the last asynchronous I/O operation resynchronized to the current thread is returned.

4.4.3 AsyncIbsta

AsyncIbsta — **ibsta** value for last asynchronous I/O operation

Synopsis

```
#include <gpib/ib.h>
```

```
int AsyncIbsta(void);
```

Description

AsyncIbsta() returns a thread-local status value related to the global variable `ibsta`. Its value corresponds to the result of the last asynchronous I/O operation resynchronized to the current thread by an `ibwait` or `ibstop` call. This function only reflects the result of the asynchronous I/O operation itself and not, for example, the `ibwait` which resynchronized the asynchronous result to the current thread. Thus the result from AsyncIbsta() is easier to interpret than ThreadIbsta(), since it is unambiguous whether the value is associated with the asynchronous I/O result, or with the function call used to resynchronize (`ibwait` or `ibstop`).

Only the status bits `END | ERR | TIMO | CMPL` are valid in the returned status byte. The rest of the bits should be ignored and will be set to zero.

This function is a Linux-GPIB extension.

Return value

A value related to `ibsta` corresponding to the last asynchronous I/O operation resynchronized to the current thread.

4.4.4 GetPAD

GetPAD — extract primary address from an Addr4882_t value

Synopsis

```
#include <gpib/ib.h>
```

```
static __inline__ unsigned int GetPAD(Addr4882_t address);
```

Description

GetPAD() extracts the primary address packed into the Addr4882_t value *address*.

Return value

The primary GPIB address (from 0 through 30) stored in *address*.

4.4.5 GetSAD

GetSAD — extract secondary address from an Addr4882_t value

Synopsis

```
#include <gpib/ib.h>
```

```
static __inline__ unsigned int GetSAD(Addr4882_t address);
```

Description

GetSAD() extracts the secondary address packed into the Addr4882_t value *address*.

Return value

The secondary GPIB address (from 0x60 through 0x7e, or 0 for none) stored in *address*.

4.4.6 MakeAddr

MakeAddr — pack primary and secondary address into an Addr4882_t value

Synopsis

```
#include <gpib/ib.h>
```

```
static __inline__ Addr4882_t MakeAddr(unsigned int pad, unsigned int sad);
```

Description

MakeAddr() generates an Addr4882_t value that corresponds to the specified primary address *pad* and secondary address *sad*. It does so by putting *pad* into the least significant byte and left shifting *sad* up to the next byte.

Examples

```
Addr4882_t addressList[ 5 ];

addressList[ 0 ] = 5 /* primary address 5, no secondary address */
addressList[ 1 ] = MakeAddr(3, 0); /* primary address 3, no secondary address */
addressList[ 2 ] = MakeAddr(7, 0x70); /* primary address 3, secondary address 16 */
addressList[ 3 ] = MakeAddr(20, MSA(9)); /* primary address 20, secondary address 9 */
addressList[ 4 ] = NOADDR;
```

Return value

An Addr4882_t value corresponding to the specified primary and secondary GPIB address.

4.4.7 MLA

MLA — generate “my listen address” command byte

Synopsis

```
#include <gpib/ib.h>
```

```
uint8_t MLA(unsigned int address);
```

Description

MLA() returns a “my listen address” **command byte** corresponding to the *address* argument. The *address* may be between 0 and 30.

Return value

The appropriate MLA command byte is returned.

4.4.8 MSA

MSA — generate “my secondary address” command byte

Synopsis

```
#include <gplib/ib.h>
```

```
uint8_t MSA(unsigned int address);
```

Description

MSA() returns a “my secondary address” **command byte** corresponding to the *address* argument. The *address* may be between 0 and 30. This macro is also useful for mangling secondary addresses from the “real” values between 0 and 30 to the range 0x60 to 0x7e used by most of the library’s functions.

Return value

The appropriate MSA command byte is returned.

4.4.9 MTA

MTA — generate “my talk address” command byte

Synopsis

```
#include <gplib/ib.h>
```

```
uint8_t MTA(unsigned int address);
```

Description

MTA() returns a “my talk address” **command byte** corresponding to the *address* argument. The *address* may be between 0 and 30.

Return value

The appropriate MTA command byte is returned.

4.4.10 PPE_byte

PPE_byte — generate “parallel poll enable” command byte

Synopsis

```
#include <gplib/ib.h>
```

```
uint8_t PPE_byte(unsigned int dio_line, int sense);
```

Description

PPE_byte() returns a “parallel poll enable” **command byte** corresponding to the *dio_line* and *sense* arguments. The *dio_line* (valid values are 1 through 8) specifies which dio line the device being configured should use to send back its parallel poll response. The *sense* argument specifies the polarity of the response. If *sense* is nonzero, then the specified dio line will be asserted to indicate that the “individual status bit” (or “ist”) is 1. If *sense* is zero, then the specified dio line will be asserted when ist is zero.

Return value

The appropriate PPE command byte is returned.

4.4.11 ThreadIbcnt and ThreadIbcntl

ThreadIbcnt and ThreadIbcntl — thread-specific ibcnt and ibcntl values

Synopsis

```
#include <gplib/ib.h>
```

```
int ThreadIbcnt(void);  
long ThreadIbcntl(void);
```

Description

ThreadIbcnt() and ThreadIbcntl() return thread-local versions of the global variables **ibcnt** and **ibcntl**.

Return value

The value of **ibcnt** or **ibcntl** corresponding to the last “traditional” or “multidevice” function called in the current thread is returned.

4.4.12 ThreadIberr

ThreadIberr — thread-specific iberr value

Synopsis

```
#include <gplib/ib.h>
```

```
int ThreadIberr(void);
```

Description

ThreadIberr() returns a thread-local version of the global variable **iberr**.

Return value

The value of **iberr** corresponding to the last “traditional” or “multidevice” function called by the current thread is returned.

4.4.13 ThreadIbsta

ThreadIbsta — thread-specific ibsta value

Synopsis

```
#include <gplib/ib.h>
```

```
int ThreadIbsta(void);
```

Description

ThreadIbsta() returns a thread-local version of the global variable `ibsta`.

Return value

The value of `ibsta` corresponding to the last “traditional” or “multidevice” function called by the current thread is returned.

5 GPIB protocol

5.1 GPIB command bytes

The meaning and values of the possible GPIB command bytes are as follows:

byte value (hexadecimal)	name	description
0x1	GTL	Go to local
0x4	SDC	Selected device clear
0x5	PPConfig (also “PPC” on non-powerpc architectures)	Parallel poll configure
0x8	GET	Group execute trigger
0x9	TCT	Take control
0x11	LLO	Local lockout
0x14	DCL	Device clear
0x15	PPU	Parallel poll unconfigure
0x18	SPE	Serial poll enable
0x19	SPD	Serial poll disable
0x20 to 0x3e	MLA0 to MLA30	My (primary) listen address 0 to 30
0x3f	UNL	Unlisten
0x40 to 0x5e	MTA0 to MTA30	My (primary) talk address 0 to 30
0x5f	UNT	Untalk
0x60 to 0x6f	MSA0 to MSA15, also PPE	When following a talk or listen address, this is “my secondary address” 0 to 15. When following a parallel poll configure, this is “parallel poll enable”. For parallel poll enable, the least significant 3 bits of the command byte specify which DIO line the device should use to send its parallel poll response. The fourth least significant bit (0x8) indicates the “sense” or polarity the device should use when responding.

byte value (hexadecimal)	name	description
0x70 to 0x7e	MSA16 to MSA30, also PPD	When following a talk or listen address, this is “my secondary address” 16 to 29. When following a parallel poll configure, this is “parallel poll disable”.
0x7f	PPD	Parallel poll disable

5.2 GPIB bus lines

Physically, the GPIB bus consists of 8 data lines, 3 handshaking lines, and 5 control lines (and 8 ground lines). Brief descriptions of how they are used follow:

bus line	description	pin number
DIO1 through DIO8	Data input/output bits. These 8 lines are used to read and write the 8 bits of a data or command byte that is being sent over the bus.	DIO1 to DIO4 use pins 1 to 4, DIO5 to DIO8 use pins 13 to 16
EOI	End-of-identify. This line is asserted with the last byte of data during a write, to indicate the end of the message. It can also be asserted along with the ATN line to conduct a parallel poll.	5
DAV	Data valid. This is a handshaking line, used to signal that the value being sent with DIO1-DIO8 is valid. During transfers the DIO1-DIO8 lines are set, then the DAV line is asserted after a delay called the “T1 delay”. The T1 delay lets the data lines settle to stable values before they are read.	6
NRFD	Not ready for data. NRFD is a handshaking line asserted by listeners to indicate they are not ready to receive a new data byte.	7
NDAC	Not data accepted. NDAC is a handshaking line asserted by listeners to indicate they have not yet read the byte contained on the DIO lines.	8
IFC	Interface clear. The system controller can assert this line (it should be asserted for at least 100 microseconds) to reset the bus and make itself controller-in-charge.	9
SRQ	Service request. Devices on the bus can assert this line to request service from the controller-in-charge. The controller can then poll the devices until it finds the device requesting service, and perform whatever action is necessary.	10

bus line	description	pin number
ATN	Attention. ATN is asserted to indicate that the DIO lines contain a command byte (as opposed to a data byte). Also, it is asserted with EOI when conducting parallel polls.	11
REN	Remote enable. Asserted by the system controller, it enables devices to enter remote mode. When REN is asserted, a device will enter remote mode when it is addressed by the controller. When REN is false, all devices will immediately return to local mode.	17

A GNU Free Documentation License

Copyright (C) 2000,2001,2002 Free Software Foundation, Inc. 59 Temple Place, Suite 330, Boston, MA 02111-1307 USA Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

A.1 PREAMBLE

The purpose of this License is to make a manual, textbook, or other functional and useful document “free” in the sense of freedom: to assure everyone the effective freedom to copy and redistribute it, with or without modifying it, either commercially or noncommercially. Secondly, this License preserves for the author and publisher a way to get credit for their work, while not being considered responsible for modifications made by others.

This License is a kind of “copyleft”, which means that derivative works of the document must themselves be free in the same sense. It complements the GNU General Public License, which is a copyleft license designed for free software.

We have designed this License in order to use it for manuals for free software, because free software needs free documentation: a free program should come with manuals providing the same freedoms that the software does. But this License is not limited to software manuals; it can be used for any textual work, regardless of subject matter or whether it is published as a printed book. We recommend this License principally for works whose purpose is instruction or reference.

A.2 APPLICABILITY AND DEFINITIONS

This License applies to any manual or other work, in any medium, that contains a notice placed by the copyright holder saying it can be distributed under the terms of this License. Such a notice grants a world-wide, royalty-free license, unlimited in duration, to use that work under the conditions stated herein. The “Document”, below, refers to any such manual or work. Any member of the public is a licensee, and is addressed as “you”. You accept the license if you copy, modify or distribute the work in a way requiring permission under copyright law.

A “Modified Version” of the Document means any work containing the Document or a portion of it, either copied verbatim, or with modifications and/or translated into another language.

A “Secondary Section” is a named appendix or a front-matter section of the Document that deals exclusively with the relationship of the publishers or authors of the Document to the Document’s overall subject (or to related matters) and contains nothing that could fall directly within that overall subject. (Thus, if the Document is in part a textbook of mathematics, a Secondary Section may not explain any mathematics.) The relationship could be a matter of historical connection with the subject or with related matters, or of legal, commercial, philosophical, ethical or political position regarding them.

The “Invariant Sections” are certain Secondary Sections whose titles are designated, as being those of Invariant Sections, in the notice that says that the Document is released under this License. If a section does not fit the above definition of Secondary then

it is not allowed to be designated as Invariant. The Document may contain zero Invariant Sections. If the Document does not identify any Invariant Sections then there are none.

The “Cover Texts” are certain short passages of text that are listed, as Front-Cover Texts or Back-Cover Texts, in the notice that says that the Document is released under this License. A Front-Cover Text may be at most 5 words, and a Back-Cover Text may be at most 25 words.

A “Transparent” copy of the Document means a machine-readable copy, represented in a format whose specification is available to the general public, that is suitable for revising the document straightforwardly with generic text editors or (for images composed of pixels) generic paint programs or (for drawings) some widely available drawing editor, and that is suitable for input to text formatters or for automatic translation to a variety of formats suitable for input to text formatters. A copy made in an otherwise Transparent file format whose markup, or absence of markup, has been arranged to thwart or discourage subsequent modification by readers is not Transparent. An image format is not Transparent if used for any substantial amount of text. A copy that is not “Transparent” is called “Opaque”.

Examples of suitable formats for Transparent copies include plain ASCII without markup, Texinfo input format, LaTeX input format, SGML or XML using a publicly available DTD, and standard-conforming simple HTML, PostScript or PDF designed for human modification. Examples of transparent image formats include PNG, XCF and JPG. Opaque formats include proprietary formats that can be read and edited only by proprietary word processors, SGML or XML for which the DTD and/or processing tools are not generally available, and the machine-generated HTML, PostScript or PDF produced by some word processors for output purposes only.

The “Title Page” means, for a printed book, the title page itself, plus such following pages as are needed to hold, legibly, the material this License requires to appear in the title page. For works in formats which do not have any title page as such, “Title Page” means the text near the most prominent appearance of the work’s title, preceding the beginning of the body of the text.

A section “Entitled XYZ” means a named subunit of the Document whose title either is precisely XYZ or contains XYZ in parentheses following text that translates XYZ in another language. (Here XYZ stands for a specific section name mentioned below, such as “Acknowledgements”, “Dedications”, “Endorsements”, or “History”.) To “Preserve the Title” of such a section when you modify the Document means that it remains a section “Entitled XYZ” according to this definition.

The Document may include Warranty Disclaimers next to the notice which states that this License applies to the Document. These Warranty Disclaimers are considered to be included by reference in this License, but only as regards disclaiming warranties: any other implication that these Warranty Disclaimers may have is void and has no effect on the meaning of this License.

A.3 VERBATIM COPYING

You may copy and distribute the Document in any medium, either commercially or noncommercially, provided that this License, the copyright notices, and the license notice saying this License applies to the Document are reproduced in all copies, and that you add no other conditions whatsoever to those of this License. You may not use technical measures to obstruct or control the reading or further copying of the copies you make or distribute. However, you may accept compensation in exchange for copies. If you distribute a large enough number of copies you must also follow the conditions in section 3.

You may also lend copies, under the same conditions stated above, and you may publicly display copies.

A.4 COPYING IN QUANTITY

If you publish printed copies (or copies in media that commonly have printed covers) of the Document, numbering more than 100, and the Document’s license notice requires Cover Texts, you must enclose the copies in covers that carry, clearly and legibly, all these Cover Texts: Front-Cover Texts on the front cover, and Back-Cover Texts on the back cover. Both covers must also clearly and legibly identify you as the publisher of these copies. The front cover must present the full title with all words of the title equally prominent and visible. You may add other material on the covers in addition. Copying with changes limited to the covers, as long as they preserve the title of the Document and satisfy these conditions, can be treated as verbatim copying in other respects.

If the required texts for either cover are too voluminous to fit legibly, you should put the first ones listed (as many as fit reasonably) on the actual cover, and continue the rest onto adjacent pages.

If you publish or distribute Opaque copies of the Document numbering more than 100, you must either include a machine-readable Transparent copy along with each Opaque copy, or state in or with each Opaque copy a computer-network location from

which the general network-using public has access to download using public-standard network protocols a complete Transparent copy of the Document, free of added material. If you use the latter option, you must take reasonably prudent steps, when you begin distribution of Opaque copies in quantity, to ensure that this Transparent copy will remain thus accessible at the stated location until at least one year after the last time you distribute an Opaque copy (directly or through your agents or retailers) of that edition to the public.

It is requested, but not required, that you contact the authors of the Document well before redistributing any large number of copies, to give them a chance to provide you with an updated version of the Document.

A.5 MODIFICATIONS

You may copy and distribute a Modified Version of the Document under the conditions of sections 2 and 3 above, provided that you release the Modified Version under precisely this License, with the Modified Version filling the role of the Document, thus licensing distribution and modification of the Modified Version to whoever possesses a copy of it. In addition, you must do these things in the Modified Version:

- A. Use in the Title Page (and on the covers, if any) a title distinct from that of the Document, and from those of previous versions (which should, if there were any, be listed in the History section of the Document). You may use the same title as a previous version if the original publisher of that version gives permission.
- B. List on the Title Page, as authors, one or more persons or entities responsible for authorship of the modifications in the Modified Version, together with at least five of the principal authors of the Document (all of its principal authors, if it has fewer than five), unless they release you from this requirement.
- C. State on the Title page the name of the publisher of the Modified Version, as the publisher.
- D. Preserve all the copyright notices of the Document.
- E. Add an appropriate copyright notice for your modifications adjacent to the other copyright notices.
- F. Include, immediately after the copyright notices, a license notice giving the public permission to use the Modified Version under the terms of this License, in the form shown in the [Addendum](#) below.
- G. Preserve in that license notice the full lists of Invariant Sections and required Cover Texts given in the Document's license notice.
- H. Include an unaltered copy of this License.
- I. Preserve the section Entitled "History", Preserve its Title, and add to it an item stating at least the title, year, new authors, and publisher of the Modified Version as given on the Title Page. If there is no section Entitled "History" in the Document, create one stating the title, year, authors, and publisher of the Document as given on its Title Page, then add an item describing the Modified Version as stated in the previous sentence.
- J. Preserve the network location, if any, given in the Document for public access to a Transparent copy of the Document, and likewise the network locations given in the Document for previous versions it was based on. These may be placed in the "History" section. You may omit a network location for a work that was published at least four years before the Document itself, or if the original publisher of the version it refers to gives permission.
- K. For any section Entitled "Acknowledgements" or "Dedications", Preserve the Title of the section, and preserve in the section all the substance and tone of each of the contributor acknowledgements and/or dedications given therein.
- L. Preserve all the Invariant Sections of the Document, unaltered in their text and in their titles. Section numbers or the equivalent are not considered part of the section titles.
- M. Delete any section Entitled "Endorsements". Such a section may not be included in the Modified Version.
- N. Do not retitle any existing section to be Entitled "Endorsements" or to conflict in title with any Invariant Section.
- O. Preserve any Warranty Disclaimers.

If the Modified Version includes new front-matter sections or appendices that qualify as Secondary Sections and contain no material copied from the Document, you may at your option designate some or all of these sections as invariant. To do this, add their titles to the list of Invariant Sections in the Modified Version's license notice. These titles must be distinct from any other section titles.

You may add a section Entitled "Endorsements", provided it contains nothing but endorsements of your Modified Version by various parties—for example, statements of peer review or that the text has been approved by an organization as the authoritative definition of a standard.

You may add a passage of up to five words as a Front-Cover Text, and a passage of up to 25 words as a Back-Cover Text, to the end of the list of Cover Texts in the Modified Version. Only one passage of Front-Cover Text and one of Back-Cover Text may be added by (or through arrangements made by) any one entity. If the Document already includes a cover text for the same cover, previously added by you or by arrangement made by the same entity you are acting on behalf of, you may not add another; but you may replace the old one, on explicit permission from the previous publisher that added the old one.

The author(s) and publisher(s) of the Document do not by this License give permission to use their names for publicity for or to assert or imply endorsement of any Modified Version.

A.6 COMBINING DOCUMENTS

You may combine the Document with other documents released under this License, under the terms defined in [section 4](#) above for modified versions, provided that you include in the combination all of the Invariant Sections of all of the original documents, unmodified, and list them all as Invariant Sections of your combined work in its license notice, and that you preserve all their Warranty Disclaimers.

The combined work need only contain one copy of this License, and multiple identical Invariant Sections may be replaced with a single copy. If there are multiple Invariant Sections with the same name but different contents, make the title of each such section unique by adding at the end of it, in parentheses, the name of the original author or publisher of that section if known, or else a unique number. Make the same adjustment to the section titles in the list of Invariant Sections in the license notice of the combined work.

In the combination, you must combine any sections Entitled "History" in the various original documents, forming one section Entitled "History"; likewise combine any sections Entitled "Acknowledgements", and any sections Entitled "Dedications". You must delete all sections Entitled "Endorsements".

A.7 COLLECTIONS OF DOCUMENTS

You may make a collection consisting of the Document and other documents released under this License, and replace the individual copies of this License in the various documents with a single copy that is included in the collection, provided that you follow the rules of this License for verbatim copying of each of the documents in all other respects.

You may extract a single document from such a collection, and distribute it individually under this License, provided you insert a copy of this License into the extracted document, and follow this License in all other respects regarding verbatim copying of that document.

A.8 AGGREGATION WITH INDEPENDENT WORKS

A compilation of the Document or its derivatives with other separate and independent documents or works, in or on a volume of a storage or distribution medium, is called an "aggregate" if the copyright resulting from the compilation is not used to limit the legal rights of the compilation's users beyond what the individual works permit. When the Document is included in an aggregate, this License does not apply to the other works in the aggregate which are not themselves derivative works of the Document.

If the Cover Text requirement of section 3 is applicable to these copies of the Document, then if the Document is less than one half of the entire aggregate, the Document's Cover Texts may be placed on covers that bracket the Document within the aggregate, or the electronic equivalent of covers if the Document is in electronic form. Otherwise they must appear on printed covers that bracket the whole aggregate.

A.9 TRANSLATION

Translation is considered a kind of modification, so you may distribute translations of the Document under the terms of section 4. Replacing Invariant Sections with translations requires special permission from their copyright holders, but you may include translations of some or all Invariant Sections in addition to the original versions of these Invariant Sections. You may include a translation of this License, and all the license notices in the Document, and any Warranty Disclaimers, provided that you also include the original English version of this License and the original versions of those notices and disclaimers. In case of a disagreement between the translation and the original version of this License or a notice or disclaimer, the original version will prevail.

If a section in the Document is Entitled “Acknowledgements”, “Dedications”, or “History”, the requirement (section 4) to Preserve its Title (section 1) will typically require changing the actual title.

A.10 TERMINATION

You may not copy, modify, sublicense, or distribute the Document except as expressly provided for under this License. Any other attempt to copy, modify, sublicense or distribute the Document is void, and will automatically terminate your rights under this License. However, parties who have received copies, or rights, from you under this License will not have their licenses terminated so long as such parties remain in full compliance.

A.11 FUTURE REVISIONS OF THIS LICENSE

The Free Software Foundation may publish new, revised versions of the GNU Free Documentation License from time to time. Such new versions will be similar in spirit to the present version, but may differ in detail to address new problems or concerns. See <http://www.gnu.org/copyleft/>.

Each version of the License is given a distinguishing version number. If the Document specifies that a particular numbered version of this License “or any later version” applies to it, you have the option of following the terms and conditions either of that specified version or of any later version that has been published (not as a draft) by the Free Software Foundation. If the Document does not specify a version number of this License, you may choose any version ever published (not as a draft) by the Free Software Foundation.

A.12 ADDENDUM: How to use this License for your documents

To use this License in a document you have written, include a copy of the License in the document and put the following copyright and license notices just after the title page:

Copyright (c) YEAR YOUR NAME. Permission is granted to copy, distribute and/or modify this document under the terms of the GNU Free Documentation License, Version 1.2 or any later version published by the Free Software Foundation; with no Invariant Sections, no Front-Cover Texts, and no Back-Cover Texts. A copy of the license is included in the section entitled "GNU Free Documentation License".

If you have Invariant Sections, Front-Cover Texts and Back-Cover Texts, replace the “with...Texts.” line with this:

with the Invariant Sections being LIST THEIR TITLES, with the Front-Cover Texts being LIST, and with the Back-Cover Texts being LIST.

If you have Invariant Sections without Cover Texts, or some other combination of the three, merge those two alternatives to suit the situation.

If your document contains nontrivial examples of program code, we recommend releasing these examples in parallel under your choice of free software license, such as the GNU General Public License, to permit their use in free software.
