

# ICA93LV

## I<sup>2</sup>C Communications Adapter User Manual

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## **1. Introduction**

The I<sup>2</sup>C Communications Adapter is a half length PC interface card designed to fit any IBM PC compatible expansion slot. Based on the Philips PCF8584 bus controller, it features full I<sup>2</sup>C bi-directional compatibility as either a master or slave. I<sup>2</sup>C connections are made via a 9 way "D" socket. This product complies with the requirements of EEC Directive 89/336 for EMC and is CE marked.

### **1.1. Packing List**

Your I<sup>2</sup>C Communications Adapter is supplied with the following items:-

- A. I<sup>2</sup>C CD ROM
- B. The ICA93 plug-in card (the actual adapter)

***TO AVOID DAMAGE TO THIS PRODUCT PLEASE BE SURE TO READ PAGE 7, SECTION 5.4 BEFORE USE***

## 2. Configuring the Adapter

**NOTE: MANY COMPONENTS ON THE ADAPTER CARD ARE STATIC SENSITIVE. OBSERVE NORMAL STATIC SENSITIVE PRECAUTIONS WHEN HANDLING THE CARD!**

The adapter is supplied in a standard configuration which should suit most applications. However, some features are link selectable. Read the following section to change the configuration.

The standard configuration is:

base address = 0310 (Hex)  
number of wait States = 1  
hardware interrupts disabled  
bus termination & protection off

### 2.1. Setting the Adapter Base Address

The card occupies a pair of PC I/O addresses and responds to input/output commands. Set the hex starting address of this pair using LK1, LK2 and LK3 within the following range:

LK3	LK2	LK1	Start Address(Hex)
0	0	0	0310
0	0	1	0312
0	1	0	0314
0	1	1	0316
1	0	0	0318
1	0	1	031A
1	1	0	031C
1	1	1	031E

The standard configuration is LK1-3 at "0" giving a start address of 0310 (Hex).

### 2.2. Wait State Generator

Data validity is assured by delaying the PC bus using the IOCHRDY signal. The number of wait states imposed on the PC bus is link selectable from 1 to 4 using LK4.

The card is supplied with LK4 in the "1" position, which is suitable for machines up to 10 MHz clock rate. **If your machine implements dynamic speed switching on I/O channel access (as do most good PCs), position 1 is correct no matter what its clock speed.**

If a PC with a faster clock is used which does not switch speed on I/O channel access, it may be necessary to increase the number of cycles delay to achieve the same absolute time delay.

Use the following table as a guideline for choosing the right position for your machine:

PC up to 10MHz	Position 1
PC over 10MHz, up to 16MHz	Position 2
PC over 16MHz, up to 20MHz	Position 3
PC over 20 MHz	Position 4

The best position is the minimum number of wait states while maintaining data security. This can easily be found by trial and error.

The ICA93 operates correctly in all 'well behaved' faster machines. In most cases just one wait state will be fine in even the fastest of machines. However, some rogue PCs that do not obey correct I/O timing may cause problems occasionally. If you suspect this is a problem, try using the adapter in another computer if possible to prove the fault. For further help regarding timings contact your ICA93 supplier for technical support. The standard configuration is with one Wait State selected.

**Important Note:** Due to the internal operation of the ICA93, it must not be accessed over the PC bus (read or written) more than once every nine of its own clock cycles. The ICA93 is clocked at 12MHz; therefore it **MUST NOT** be accessed more than once every 0.75 microseconds. If this requirement is not observed operation may become erratic. This is usually only encountered in very fast PCs, however it must be borne in mind when writing software if say the system hardware might be updated in the future. When timing problems are encountered it is invariably this which is causing the difficulties, not the selection of the number of wait states. This is automatically controlled by the Windows DLLs, but must be checked by the programmer when using the DOS routines.

### 2.3. Interrupt Generation

The adapter is designed for either polled or interrupt driven operation. Interrupts are generated after the sending or reception of any byte on the I<sup>2</sup>C Bus. The pulse is negative going with a duration of approx. 100nS, the interrupt being signalled by the rising edge of this pulse.

Link 5 allows the selection of which PC interrupt line the card is connected to:

LK5 position	PC Interrupt
NONE	DISABLED
2	IRQ2
3	IRQ3
4	IRQ4
7	IRQ7

As can be seen, the card is capable of connecting to four out of the eight available PC I/O interrupts. The final choice will depend on what other peripherals are connected to the PC.

The standard configuration is with the interrupts disabled, i.e. LK5 in the "NONE" position.

### 2.4. Bus Termination and Protection

Normally the system to which the I<sup>2</sup>C Communications Adapter is to be connected should already have master pull up resistors fitted to the SCL and SDA lines. If this is not the case, LK10 and LK12 can be used to connect 4K7 pull up resistors to the variable supply on these lines. The standard configuration is with these resistors disconnected.

The SCL and SDA lines are protected by 100R series resistors before exiting the adapter via the 9 way "D" socket. Upstream of the series resistors, the SCL and SDA pins on the PCF8584 are pulled up with high value resistors (10K). These ensure that the I<sup>2</sup>C Bus is in a defined state even if no other devices are connected. The standard configuration is with these resistors connected using LK9 and LK11

LK13 and LK14 connect optional protection diodes to the SCL and SDL lines. When selected, these lines are clamped to the 0V and variable supply lines giving protection against transients. If these diodes are connected, the external I<sup>2</sup>C system will not function if the adapter is connected but not powered up. The standard configuration is with these diodes disconnected.

### 2.5. Installing the Adapter

**NOTE: BEFORE INSTALLING THE ADAPTER IN YOUR PC, OBSERVE ANY SAFETY PRECAUTIONS GIVEN BY THE MANUFACTURER OF THE COMPUTER.**

**NORMAL ANTI-STATIC HANDLING PRECAUTIONS SHOULD BE OBSERVED TO AVOID ANY DAMAGE TO THE ICA93 OR THE COMPUTER.**

Switch off the power to the PC and remove the mains plug from its socket before opening the case.

Plug the adapter into any available slot. Ensure the fixing screw is replaced in the computer rear panel to hold the adapter firmly in place.

Close the case, reconnect the mains lead and switch on the computer.

### 3. Connecting the Adapter to your System

#### 3.1. Connector Pinout

All external connections are made via a 9 way "D" socket:

Pin	Normal Mode
1	0V
2	0V
3	0V
4	0V
5	NC
6	SDA (Bi-directional)
7	+V Variable bus voltage
8	SCL (Bi-directional)
9	NC

**NOTE: THE PINS MARKED NC MUST NOT BE CONNECTED IN NORMAL MODE.**

#### 3.2. Normal/Long Distance Mode

The ICA93 does NOT support the 4-wire long distance mode which the 5V only ICA90 model can operate in. This is the only incompatibility between the two models.

#### 3.3. Bus Capacitance Limitations/Cable Choice

The maximum allowable capacitance on the I<sup>2</sup>C bus in normal mode depends on the value of the SCL and SDA master pull-ups, but never exceeds 400pF. Refer to Phillips Technical Handbook Book 4 Parts 12a and 12b for further details (see Section 8 - Further Information for references). Care should be taken in choosing a length and type of interconnecting cable, which will not exceed this limit.

For most systems with a distance of a few metres between the I<sup>2</sup>C Communications Adapter and the target system, screened cable is NOT recommended, as it is likely to introduce too much capacitance. However, the EMC performance of an unscreened cable is always potentially poorer than a screened one. The Adapter's EMC performance even with an unscreened cable is good - but this may not be true of the target system! If you are in any doubt as to the best way to connect up your system with EMC in mind please contact your supplier or Calibre for advice.

#### 3.4. Variable Voltage Bus Power Supply

Pin 7 on the "D" connector is connected to the variable bus voltage power rail. Power for external circuitry can be drawn from here, but care should be taken never to short it to 0V or to exceed 250mA loading. It is short circuit and overload protected by a self-resetting thermal fuse but prolonged shorting could cause the ICA93 to generate an excessive amount of heat inside your computer.

When shipped to you, the bus voltage was pre-set at 3.3V for use with low voltage memories. You can adjust the voltage between 2V and 6V by inserting a small screwdriver through the hole in the card mounting bracket. As you adjust the voltage (you can monitor it by connecting a meter to pin 7 of the bus connector) the bus logic levels will track, keeping at 30% / 70% of supply for low and high level thresholds respectively.

The Links 6, 7, and 8 are factory set to VAR and **MUST NOT BE MOVED.**

**Your ICA93 has been factory set for use on 3.3V I<sup>2</sup>C bus systems. Use on 5V I<sup>2</sup>C bus systems without adjusting the voltage control WILL CAUSE PERMANENT DAMAGE to the IC93. The fault is factory detectable and you WILL BE CHARGED FOR THE REPAIR.**

## 4. Getting Started

### 4.1. Resetting the Adapter

A reset forces the adapter into a well defined state, ready for initialisation. The card uses the same reset line as the PC so either a power up or hard reset (press the <RESET> button on your PC) will suffice.

### 4.2. Introduction to the Utilities

The utilities supplied with the adapter contain simple DOS routines in both C and TurboBASIC, which can be used for setup and basic communications. This is a list of the DOS utilities supplied:

#### C Library/Programs

Procedure or File Name	Subroutine Name	Brief Functional Description
i2c.h	setup	Sets user defined initial conditions.
	getstatus	Reads status register.
	sendaddress	Sends slave address, data transmission mode and start signal.
	sendstop	Sends stop signal.
	writebyte	Writes a byte of data to a previously specified address.
	readbyte	Reads a byte of data from a previously specified address.
	restart	Sends Restart and slave address of device, which is to be communicated with, without sending a Stop.
count.c		Sends a counting sequence of 0 to 99 to a seven segment display driver.
count.exe		Executable version of above.
ram.c		Writes then reads back data from a series of RAM locations. Checks for correct readback.
ram.exe		Executable version of above.
setup.c		Sets up typical initial conditions – Own Slave Address = AE (Hex), SCL = 90KHz; assumes adapter's base address = 0310 (Hex).
setup.exe		Executable version of above.

#### TurboBASIC Library/Programs

Procedure or File Name	Subroutine Name	Brief Functional Description
i2c.inc	setup	Sets user defined initial conditions.
	FNgetstatus%	Reads status register.
	sendaddress	Sends slave address, data transmission mode and start signal.
	sendstop	Sends stop signal.
	writebyte	Writes a byte of data to a previously specified address.
	FNreadbyte%	Reads a byte of data from a previously specified address.
	restart	Sends restart and slave address of device which is to be communicated with, without sending a Stop.
count.bas		Sends a counting sequence of 0 to 99 to a seven segment display driver.
tbcount.exe		Executable version of above.
ram.bas		Writes then reads back data from a series of RAM locations. Checks for correct readback.
tbram.exe		Executable version of above.

16 bit Windows DLLs for use with Visual Basic 3.0 and Microsoft C++1.5 are included on the disc. See Section 7.3 for a detailed description of the routines available. All library functions listed for the DOS routines are covered. Additionally some extra multiple operation functions are supplied.

## 5. Using the Utilities

Each utility is documented in a standard format, which lists its name, usage, function, and effect on the adapter is given. Following a reset, the adapter should be setup prior to any data transfer.

### 5.1. C Routines

#### 5.1.1. I<sup>2</sup>C Setup/Initialisation Routine

Name: setup(base, own, sclk)  
Usage: setup(base, own, sclk);  
Function: procedure to set up I<sup>2</sup>C Communications Adapter.

Parameters are:

int base                    base address of adapter set by links on circuit board.  
int own                    I<sup>2</sup>C address to which the adapter is to respond in slave mode. This forms the upper 7 bits of the 8 bit address; the lowest bit being the Read (1) or Write (0) bit. This means that if own = 0x57, the card will respond to a Write to address 0xAE and a Read to address 0xAF. Be sure not to select an address that is already in use by any other device in your I<sup>2</sup>C system. If own = 0x00 the adapter will monitor all I<sup>2</sup>C bus information but will not affect any data transfers, thus acting as a bus monitor.  
int sclk                    the SCL clock rate (bit rate for I<sup>2</sup>C serial bus).

Value of sclk	Approximate SCL (kHz)
0	90
1	45
2	11
3	1.5

Value Returned:none.

I<sup>2</sup>C status on exit from routine:

The I<sup>2</sup>C Communications Adapter will have the serial interface enabled; also data reception acknowledge will be enabled. The status register will contain 0x81 (assuming that no other masters exist on the I<sup>2</sup>C system, if this is not the case then the contents of the status register will also depend on externally generated bus activity).

Example Usage: (see also sample programs)

```
#include <stdio.h>
#include <dos.h>            /*Optional, but recommended if your compiler */
                          /*supports DOS I/O functions */
#include <i2c.h>            /*This contains the I2C routines */
main
{
    int base, own, sclk;
    base = 0x310;            /* Adapter's base address = 0x310 (hex) */
    own = 0x57;            /* Own slave address set to 0x57 (hex) */
    sclk = 1;              /* Serial clock rate set to 45KHz */
    setup(base, own, sclk);
    printf("I2C Communications Adapter initialised\n");
}
/* This will set up the I2C Communications Adapter with a base */
/* address of 0x310, an I2C slave address of 0xAE and a SCL */
/* clock rate of approximately 45KHz */
```

#### 5.1.2. I<sup>2</sup>C Status Checking Routine

Name: getstatus(controladdress)  
Usage: status = getstatus(controladdress);  
Function: function to read status register of I<sup>2</sup>C Communications Adapter.

Parameters are:

int controladdress      address of I<sup>2</sup>C control register. This is equal to 1+(base address of adapter set by links on circuit board).

Value Returned:

int <status>            where status is an integer from 0x00 to 0xFF which indicates the current status of I<sup>2</sup>C Communications Adapter. See Appendix A for details of the status values returned.

I<sup>2</sup>C status on exit from routine:

The status of the I<sup>2</sup>C Communications Adapter will not be affected by using the getstatus function.

Example Usage: (see also sample programs)

```
#include <stdio.h>
#include <dos.h>            /*Optional, but recommended if your compiler */
                             /*supports DOS I/O functions */
#include <i2c.h>            /*This contains the I2C routines */
main
{
    int status, base, controladdress;
    base = 0x310;            /*Adapter's base address = 0x310 (hex) */
    controladdress = base + 1;
    Status = getstatus (controladdress);
    printf("I2C Communications Adapter Status = %x\n", status);
}
/*This will read the I2C Communications Adapter's current status */
```

### 5.1.3. I<sup>2</sup>C Address and Start Sending Routine

Name:                    sendaddress (base, slv, setnack)

Usage:                   sendaddress(base, slv, setnack)

Function:                procedure to send Start and slave address of device that is to be communicated with.

Parameters are:

int base                 the base address of the I<sup>2</sup>C Communications Adapter set by links on circuit board.

int slv                  the slave address of the device which is to be communicated with. This will be an even number if the adapter is to write to the slave, add 1 to get an odd number if the adapter is to read from the slave.

int setnack              this controls whether the I<sup>2</sup>C Communications Adapter transmits an Acknowledge down the I<sup>2</sup>C Bus on reception of a byte. The last byte received during a transfer must not be acknowledged, in all other cases acknowledge is enabled, if setnack = 1 then acknowledge is disabled. Therefore, if a read (odd numbered) address is being sent AND only 1 byte is to be read, setnack should be set to = 1; in all other cases it must be set = 0.

Value Returned:none.

I<sup>2</sup>C status on exit from routine

The status of the I<sup>2</sup>C/ the Communications Adapter will be either 0x00 - bus busy and unread data in the data register or 0x80 - bus busy and no unread data in the data register when a Start and Slave Address have been successfully transmitted (see Appendix A for details of Status Codes).

Example Usage:            (see also sample programs)

```
#include <stdio.h>
#include <dos.h>            /* Adapter's base address = 0x310 (hex) */
                             /* compiler supports DOS I/O functions */
#include <i2c.h>            /* This contains the I2C routines */
main
```



```

{
    int base, slv, setnack;
    base = 0x310;          /* Adapter's bas address = 0x310 (hex) */
    slv = 0xa0;           /* I2C Address of slave, this is a typical */
                          /* write for an I2C static RAM or EEPROM */
    setnack = 0;          /* Enable Acknowledge (see parameter */
                          /* descriptions) */
    sendaddress(base, slv, setnack);
    printf("Start and I2C Slave Address sent\n");
}
/* This will send a start and the I2C Slave Address of the device */
/* to be communicated with. */

```

#### 5.1.4. I<sup>2</sup>C Read Data Byte from Slave Routine

Name: readbyte(base, setnack)

Usage: data = readbyte(base, setnack);

Function: To read a byte of data from a slave device whose slave address has already been sent by sendaddress. Can be used to disable acknowledge after reading data if it is the last but one byte to be read.

**Note: First byte read after read-address is always that address and should be discarded. This byte should be ignored when working out when to acknowledge/not acknowledge.**

Parameters are:

int base                   The base address of the I<sup>2</sup>C Communications Adapter set by links on circuit board.

int setnack                This controls whether the I<sup>2</sup>C Communications Adapter transmits an Acknowledge down the I<sup>2</sup>C Bus on reception of a byte. The last byte received during a transfer must not be acknowledged, in all other cases must be enabled. If setnack = 0 then acknowledge is enabled, if setnack = 1 then acknowledge is disabled. Therefore, if the LAST BUT ONE byte is to be read, setnack should be set to = 1; in all other cases it must be set = 0. (in case of reading 1 byte only, acknowledge will have been disabled by sendaddress and so should now be enabled again after reading the data, hence setnack = 0 for reading a single byte of data.)

Value Returned:

int <data>                The function reads the byte of data and returns an integer equal to the value read.

I<sup>2</sup>C status on exit from routine:

The status of the I<sup>2</sup>C Communications Adapter will be either 0x00 - bus busy and unread data in the data register or 0x80 - bus busy and no unread data in the data register depending on whether any more bytes of data have been transmitted by the slave device which is being read. (See Appendix A for details of the status Codes).

Example Usage: (see also sample programs)

```

#include <stdio.h>
#include <dos.h>          /* Optional, but recommended if your compiler */
                          /* supports DOS I/O functions */
#include <i2c.h>          /* This contains the I2C functions */
main
{
    int base, setnack, data;
    base = 0x310;        /* Adapter's base address = 0x310 (hex) */
    setnack = 0;        /* Enable acknowledge - only one byte it to */
                          /* be read (see parameter descriptions) */
    data = readbyte(base, setnack);
    printf("Data read was %x\n", data);
}

```

```
/* This will read a byte of data from a slave previously addressed */
/* by and with acknowledge already disabled by sendaddress. */
/* After reading the data, acknowledge will be re-enabled. */
```

### 5.1.5. Write Data Byte to Slave Routine

Name: writebyte(base, data)

Usage: writebyte(base, data)

Function: procedure to write a byte of data to a slave device whose slave address has already been sent by sendaddress.

Parameters are:

int base                   The base address of the I<sup>2</sup>C Communications Adapter set by links on circuit board.

int data                   The byte of data which is to be written to the slave device.

Value Returned:none.

I<sup>2</sup>C status on exit from routine:

The status of the I<sup>2</sup>C Communications Adapter will be 0x00 - bus busy and data in the data register transmitted successfully. (See Appendix A for details of Status Codes).

Example Usage: (see also sample programs)

```
#include <stdio.h>
```

```
#include <dos.h>
```

```
/* Optional, but recommended if your compiler */
```

```
/* supports DOS I/O functions */
```

```
#include <i2c.h>
```

```
/* This contains the I2C routines */
```

```
main
```

```
{
```

```
    int base, data;
```

```
    base = 0x310;
```

```
                          /* Adapter's base address = 0 x 310- (hex) */
```

```
    data = 0x69;
```

```
                          /* Data byte which is to be transmitted */
```

```
    writebyte (base, data) ;
```

```
    printf("Data has been transmitted\n");
```

```
}
```

```
/* This will write a byte of data to a slave previously addressed */
```

```
/* by sendaddress. */
```

### 5.1.6. Send an I<sup>2</sup>C Stop Routine

Name: sendstop(controladdress)

Usage: sendstop(controladdress);

Function: procedure to send a stop (end of communication signal) down the I<sup>2</sup>C Bus, ending a transmission or reception with a slave which was addressed previously by sendaddress.

Parameters are:

int controladdress       the address of the I<sup>2</sup>C Communications Adapter control register, equal to 1+(base address set by links on circuit board).

Value Returned:none.

I<sup>2</sup>C status on exit from routines:

The status of the I<sup>2</sup>C/ the Communications Adapter will be 0x81 - bus idle and no unread/untransmitted data in the data register. Note - this may not be the case in a system where there is another master as well as the I<sup>2</sup>C Communications Adapter, since this other master may well have taken control of the bus by the time a program next uses getstatus to read the status register. (See Appendix A for details of Status Codes).

Example Usage: (see also sample programs)

```
#include <stdio.h>
```

```

#include <dos.h>      /* Optional, but recommended if your compiler */
                    /* supports DOS I/O functions */
#include <i2c.h>      /* This Contains the I2C routines */
main
{
    int base, controladdress;
    base = 0x310;      /* Adapter's base address = 0x310 (hex) */
    controladdress = base + 1; /* Control Register address */
    sendstop(controladdress);
    printf("Stop has been transmitted\n");
}/* This will write a Stop to the I2C Bus */

```

### 5.1.7. I<sup>2</sup>C Restart and Address Sending Routine

Name: restart(base, slv, setnack)

Usage: restart(base, slv, setnack)

Function: Procedure to send a Restart and the slave address of device that is to be communicated with, without a Stop having been sent at the end of last transmission/reception. This routine is particularly useful for reading memories which must first have a data pointer written to them to select where the read is to occur from, and must have their address sent as a Restart to proceed with the read operation.

Parameters are:

int base            the base address of the I<sup>2</sup>C Communications Adapter set by links on the circuit board.

int slv            the slave address of the device which is to be communicated with. This will be an even number if the adapter is to write to the slave, add 1 to get an odd number if the adapter is to read from the slave.

int setnack        this controls whether the I<sup>2</sup>C communications Adapter transmits an Acknowledge down the I<sup>2</sup>C Bus on reception of a byte. The last byte received during a transfer must not be acknowledged, in all other cases acknowledge must be enabled, if setnack = 1 then acknowledge is disabled. Therefore, if a read (odd numbered) address is being sent AND only 1 byte is to be read, setnack should be set to = 1; in all other cases it must be set = 0.

Value Returned:none.

I<sup>2</sup>C status on exit from routine:

The status of the I<sup>2</sup>C/ the Communications Adapter will be either 0x00 - bus the busy and unread data in the data register or 0x80 - bus busy and no unread data in the data register when a Restart and Slave Address have been successfully transmitted (see Appendix A for details of status codes).

Example Usage: (see also sample programs)

```

#include <stdio.h>
#include <dos.h>      /* Optional, but recommended if your compiler */
                    /* supports DOS I/O functions */
#include <i2c.h>      /* This contains the I2C functions */
main
{
    int base, slv, setnack;
    base = 0x310;      /* Adapter's base address = 0x310 (hex) */
    slv = 0xa1;        /* I2C Address of slave, this is a typical read */
                    /* address for an I2C static RAM or EEPROM */
    setnack = 0;      /* Enable Acknowledge (see parameter descriptions)*/
    restart(base, slv, setnack);
}

```

## 5.2. TurboBASIC Routines

### 5.2.1. I<sup>2</sup>C Setup/Initialisation Routines

Name: setup (baseaddr%, own%, sclk%)  
 Usage: call setup(baseaddr%, own%, sclk%)  
 Function: procedure to set up I<sup>2</sup>C Communications Adapter.  
 Parameters are:

baseaddr% base address of adapter set by links on circuit board.  
 own% I<sup>2</sup>C address to which the adapter is to respond in slave mode. This forms the upper 7 bits of the 8 bit address, the lowest bit being the Read(1) or Write (0) bit. This means that if own% = &h57, the card will respond to a Write to address &hAF. Be sure not to select an address that is already in use by any other device in your I<sup>2</sup>C system. If own% &h00 the adapter will monitor all I<sup>2</sup>C bus information but will not affect any data transfers, thus acting as a bus monitor  
 sclk% the SCL clock rate (bit rate for I<sup>2</sup>C serial bus).

Value of sclk%	Approximate SCL (kHz)
0	90
1	45
2	11
3	1.5

Value Returned:none.

I<sup>2</sup>C status on exit from routine:

The I<sup>2</sup>C Communications Adapter will have the serial interface enabled, also data reception acknowledge will be enabled. The status register will contain &h81 (assuming that no other masters exist on the I<sup>2</sup>C system, if this is not the case then the contents of the status register will also depend on externally generated bus activity).

Example Usage: (see also sample programs)  
`$include "i2c.inc"` \* This contains the I<sup>2</sup>C routines\*  
`baseaddr% = &h310` \* Adapter's base address = &h310 (hex) \*  
`own% = &h57` \* Own slave address set to &h57 (hex) \*  
`sclk% = 1` \* Serial clock rate set to 45KHz \*  
`call setup(baseaddr%, own%, sclk%)`  
`print"I2C Communications Adapter initialised"`  
 \* This will set up the I<sup>2</sup>C Communications Adapter with a base address \*  
 \* of &h310, an I<sup>2</sup>C slave address of &hAE and a SCL clock rate of \*  
 \* approximately 45KHz \*

### 5.2.2. I<sup>2</sup>C Status Checking Routine

Name: FNgetstatus%(Controladdress%)  
 Usage: status% = FNgetstatus%(controladdress%)  
 Function: function to read status register of I<sup>2</sup>C Communications Adapter.  
 Parameters are:

controladdress% address of I<sup>2</sup>C control register. This is equal to 1+(base address of adapter set by links on circuit board).

Value Returned:

<status%> where status is an integer from &h00 to &hFF which indicates the current status of the I<sup>2</sup>C communications Adapter. Appendix A for details of the status values returned.

I<sup>2</sup>C status on exit from routine:

The status of the I<sup>2</sup>C Communications Adapter will not be affected by using the FNgetstatus% function.

Example Usage: (see also sample programs)  
`$include "i2c.inc"` \* This contains the I<sup>2</sup>C routines \*

```

baseaddr% = &h310    /* adapter's base address = 0x310 (hex) *
controladdress% = baseaddr% + 1
status% = FNgetstatus%(controladdress%)
print"I2C Communications Adapter Status = ";status%
/* This will read the I2C Communications Adapter's current status *

```

### 5.2.3. I<sup>2</sup>C Address and Start Sending Routine

Name: sendaddress(baseaddr%, slv%, setnack%)

Usage: call sendaddress(baseaddr%, slv%, setnack%)

Function: procedure to send Start and slave address of device that is to be communicated with.

Parameters are:

baseaddr% the base address of the I<sup>2</sup>C Communications Adapter set by links on circuit board.

slv% the slave address of the device which is to be communicated with. This will be an even number if the adapter is to write to the slave, add 1 to get an odd number if the adapter is to read from the slave.

setnack% this controls whether the I<sup>2</sup>C Communications Adapter transmits an Acknowledge down the I<sup>2</sup>C Bus on reception of a byte. The last byte received during a transfer must not be acknowledged, in all other cases acknowledge must be enabled. If setnack% = 0 then acknowledge must be enabled, if setnack% = 1 then acknowledge is disabled. Therefore, if a read (odd numbered) address is being sent AND only 1 byte is to be read, setnack% should be set to = 1; in all other cases it must be set = 0.

Value Returned:none.

I<sup>2</sup>C Status on exit from routine:

The status of the I<sup>2</sup>C Communications Adapter will be either &h00 - bus busy and unread data in data register or &h80 - bus busy and no unread data in data register when a Start and Slave Address have been successfully transmitted (see Appendix A for details of status codes).

Example Usage: (see also sample programs)

```

#include "i2c.inc"    /* This contains the I2C routines*
baseaddr% = &h310    /* Adapter's base address = 0x310 (hex) *
slv% = &ha0          /* IC Address of slave, this is a typical write *
                    /* address for an I2C static RAM or EEPROM *
setnack% = 0         /* Enable Acknowledge (see parameter descriptions) *
call sendaddress (baseaddr%, slv%, setnack%)
print"Start and I2C Slave Address sent"
/* This will send a Start and the I2C Slave Address of the device to be communicated with. *

```

### 5.2.4. I<sup>2</sup>C Read Data Byte from Slave Routine

Name: FNreadbyte%(baseaddr%, setnack%)

Usage: databyte% = FNreadbyte%(baseaddr%, setnack%)

Function: function to read a byte of data from a slave device whose slave address has already been sent by sendaddress. Can be used to disable acknowledge after reading data if it is the last but one byte to be read.

Parameters are:

baseaddr% the base address of the I<sup>2</sup>C Communications Adapter set by links on circuit board.

setnack% this controls whether the I<sup>2</sup>C Communications Adapter transmits and Acknowledge down the I<sup>2</sup>C Bus on reception of a byte. The last byte received during a transfer must not be acknowledged, in all other cases acknowledge must be enabled. If setnack% = 0 then acknowledge is enabled, if setnack% = 1 then acknowledge is disabled. Therefore, if the LAST BUT ONE byte is to be read, setnack% should be set to =1; in all other cases it must be set = 0. (In the case of reading 1 byte only, acknowledge will have been disabled by sendaddress and so should now be enabled again after reading the data, hence setnack% = 0 for reading a single byte of data.)

Value Returned:

<databyte%> the function reads the byte of data and returns an integer equal to the value read.

I<sup>2</sup>C status on exit from routine:

The status of the I<sup>2</sup>C/ the Communications Adapter will be either &h00 - bus the busy and unread data in the data register or &h80 - bus busy and no unread data in the data register depending on whether any more bytes of data have been transmitted by the slave device which is being read. (See Appendix A for details of Status Codes).

Example Usage: (see also sample programs)  
\$include "i2c.inc" \* This contains the I<sup>2</sup>C routines \*  
baseaddr% = &h310 \* Adapter's base address = 310 (hex) \*  
setnack% = 0 \* Enable Acknowledge - only one byte is to be read \*  
\* (see parameter descriptions) \*

```
databyte% = FNreadbyte%(baseaddr%, setnack%)  
print "Data read was ";databyte%  
* This will read a byte of data from a slave previously addressed by and with acknowledge already *  
* disabled by sendaddress. After reading the data, acknowledge will be re-enabled.*
```

### 5.2.5. Write Data Byte to Slave Routine

Name: writebyte(baseaddr%, databyte%)

Usage: call writebyte(baseaddr%, databyte%)

Function: procedure to write a byte of data to a slave device whose slave address has already been sent by sendaddress.

Parameters are:

baseaddress% the base address of the I<sup>2</sup>C Communications Adapter set by links on circuit board.

databyte% the byte of data which is to be written to the slave device.

Value Returned:none.

I<sup>2</sup>C status on exit from routine:

The status of the I<sup>2</sup>C Communications Adapter will be &h00 - bus busy and data in the data register transmitted successfully. (See Appendix A for details of Status Codes).

Example Usage: (see also sample programs)  
\$include "i2c.inc" \* This contains the I<sup>2</sup>C routines \*  
baseaddr% = &h310 \* Adapter's base address = 310 (hex) \*  
databyte% = &h69 \* Data byte which is to be transmitted\*  
call writebyte(baseaddr%, data byte%)  
print "Data has been transmitted"  
\* This will write a byte of data to a slave previously addressed by sendaddress. \*

### 5.2.6. Send an I<sup>2</sup>C Stop Routine

Name: sendstop(controladdress%)

Usage: call sendstop (controladdress%)

Function: procedure to send a Stop (end of communication signal) down the I<sup>2</sup>C Bus, ending a transmission or reception with a slave that was address previously by sendaddress.

Parameters are:

controladdress% The address of the I<sup>2</sup>C Communications Adapter control register, equal to 1+(base address set by links on circuit board).

Value Returned:none.

I<sup>2</sup>C status on exit from routine:

The status of the I<sup>2</sup>C/ the Communications Adapter will be &h81 - bus idle and no unread/untransmitted data in the data register. Note - this may not be the case in a system where there is another master as well as the I<sup>2</sup>C Communications Adapter, since this other master may well have taken control of the bus by the time a program next uses getstatus to read the status register. (See Appendix A for details of Status Codes).

Example Usage: (see also sample programs)  
\$include "i2c.inc" \* This contains the I<sup>2</sup>C routines\*  
baseaddr% = &h310 \* Adapter's base address = 310 (hex) \*  
controladdress% = baseaddr% + 1 \* Control Register address \*  
call sendstop(controladdress%)  
print"Stop has been transmitted"  
\* This will write a stop to the I<sup>2</sup>C Bus\*

### 5.2.7. I<sup>2</sup>C Restart and Address Sending Routine

Name: restart(baseaddr%, slv% setnack%)

Usage: call restart(baseaddr%, slv%, setnack%)

Function: procedure to send a Restart and the slave address of device that is to be communicated with, without a Stop having been sent at the end of the last transmission/reception. This routine is particularly useful for reading memories which must first have a data pointer written to them to select where the read is to occur from, and must then have their read address sent with a Restart to proceed with the read operation.

Parameters are:

baseaddr% the base address of the I<sup>2</sup>C Communications Adapter set by links on circuit board.

slv% the slave address of the device which is to be communicated with. This will be an even number if the communicated with. This will be an even number if the adapter is to write to the slave, add 1 to get an odd number if the adapter is to read from the slave.

setnack% this controls whether the I<sup>2</sup>C Communications Adapter transmits an Acknowledge down the I<sup>2</sup>C Bus on reception of a byte. The last byte received during a transfer must not be acknowledged, in all other cases acknowledge must be enabled. If setnack% = 0 then acknowledge is enabled, if setnack% = 1 then acknowledge is disabled. Therefore, if a read (odd numbered) address is being sent AND only 1 Byte is to be read, setnack% should be set to = 1; in all other cases it must be set = 0.

Value Returned:none.

I<sup>2</sup>C status on exit from routine:

The status of the I<sup>2</sup>C/ the Communications Adapter will be either &h00 - bus the busy and unread data in the data register or &h80 - bus busy and no unread data in the data register when a Restart and Salve Address have been successfully transmitted (see Appendix A for details of Status Codes).

Example Usage: \* This contains the I<sup>2</sup>C routines\*  
\$include "i2c.inc" \* Adapter's base address = 310 (hex) \*  
baseaddr% = &h310  
Revision 1.7  
09/12/1999

```

slv% = &ha1          * I2C Address of slave, this is a typical read address *
                    * for an I2C static RAM or EEPROM*
setnack% = 0        * Enable Acknowledge (see parameter descriptions) *
call restart(baseaddr%, slv%, setnack%)
print"Restart and I2C Slave Address sent"
* This will send a Restart and the I2C Slave Address of the device to *

```

### 5.3. DLLs for Programming in Microsoft Windows 3.X Environments

#### 5.3.1. Files

readme.doc	User Information
lc\i2inc.h	"C" function prototypes
lc\cali2c.lib	I <sup>2</sup> C "C" library
vb30\cali2c.bas	Visual Basic 3.0 declarations
vb30cali2c.dll	I <sup>2</sup> C Visual Basic dynamic link library

#### C functions – Function Prototypes

The following function prototypes are required by the DLL, these are defined in the file I2CINC.H

```

Void far_pascal_export setup (int baseaddress, int ownaddress, int sclk, int statuswait);
int far_pascal_export sendaddress (int sendaddress, int setnack);
int far_pascal_export restart (int slaveaddress, int setnack);
int far_pascal_export getstatus (void);
int far_pascal_export writebyte (int wrData);
int far_pascal_export readbyte (int setnack);
int far_pascal_export sendstop (void);
int far_pascal_export recover (void);
int far_pascal_export sendbytes (int_far *transferarray);
int far_pascal_export getbytes (int_far *transferarray);
void far_pascal_export slavelastbyte (void);

```

To ensure the prototypes are added correctly copy the file I2CINC.H into the directory containing your project and add the line: #include "I2CINC.H"

Remember to add the library CALI2C.LIB to your project make file.

#### **Visual Basic 3.0 function**

Add the file CALI2.BAS to your project, this contains the declarations for the procedures within the DLL.

If the DLL is not in the root directory change the path to the DLL to suit your system.

The sendbytes and getbytes functions pass the transfer array to the DLL by reference, the following example indicates how to do this:

```

ReDim transferarray (0 to 258) 'remember 3 locations are required for the slave write and word
                               addresses so array allows 256 bytes of data.

transferarray (0) = &HA0      'slave write address.
transferarray (1) = &H00      'slave word address.
Transferarray (2) = 256      'the number of bytes.

Bytes_sent = sendbytes(transferarray(0))

```

#### DLL function descriptions – Applies to both C++ and Visual Basic

##### **setup**

*Function specification*                      Void setup(int baseaddress, int ownaddress, int sclk, int statuswait)



baseaddress is the address at which the adapter has been installed, e.g. 310H

ownaddress I2C address to which the adapter is to respond in slave mode. This forms the upper 7 bits of the 8 bit address, the lowest bit being the read (1) or write (0) bit. This means that if ownaddress = 57H the card will respond to a write address of AEH and a read address of AFH.

Statuswait is a period of time (in microseconds) to wait for the required bus status. If this time-out expires the I<sup>2</sup>C functions will exit returning an error code.

sclk is clock rate (bit rate for the I<sup>2</sup>C serial bus) when operating as a master.

Value of sclk	Approximate SCL-kHz
0	90
1	45
2	11
3	1.5

*Parameters returned*

none.

*Prerequisites*

none.

*Functional description*

This function characterises the PC and initialises adapter ready for I<sup>2</sup>C transfers.

### **sendaddress**

*Functional specification*

Int sendaddress (int slaveaddress, int setnack)

slaveaddress is the address to be accessed via the I2C, e.g. A0H

setnack 1 for no acknowledge 0 for acknowledge – see Functional Description

*Parameters returned*

ErrCode. If the transfer time out occurs error code 8001H is returned otherwise the status is returned.

*Prerequisites*

adapter must be configured by running **setup**.

*Functional description*

The function waits for the bus to be free. Then sends the slave address with the appropriate acknowledge.

The acknowledge is set ready for the data transfer after the address and hence in read mode (odd address being sent) if only one byte is to be read the setnack parameter must equal 1. If more than one byte is to be read or if in write mode (even address being sent) then setnack must equal 0.

### **writebyte**

*Function specification*

Int writebyte (int wrData)

wrData is the byte of data to be written.

*Parameters returned*

ErrCode. If the transfer time out occurs error code 8004H is returned otherwise the status is returned.

*Prerequisites*

Adapter must be configured using **setup**, start and write address sent by **sendaddress**.

*Functional description*

The function writes the data to the adapter and then waits for it to be sent. Should a time-out occur during the sending of the data then error code 8004H is returned, otherwise the status is returned. Writebyte is compatible with both master write and slave write modes.

### **readbyte**

*Function specification*

Int readbyte (int setnack)

	Setnack 1 for no acknowledge 0 for acknowledge.
<i>Parameters returned</i>	I <sup>2</sup> Cdata, the data read, if a time-out occurs the ErrCode 8005H is returned.
<i>Prerequisites</i>	Adapter must be configured using <b>setup</b> , start and read address sent by <b>sendaddress</b> .
<i>Functional Description</i>	<p>If setnack is 1 the function writes 40H to the control register to establish the correct acknowledge procedure. The data is read from the adapter.</p> <p>IMPORTANT: SETNACK MUST = 1 WHEN READING THE LAST AND THE LAST BUT ONE BYTES IN A SEQUENCE OF BYTES</p> <p>SETNACK MUST = 0 FOR ALL OTHER READS. IF THIS FORMAT IS NOT STRICTLY FOLLOWED THEN THE ADAPTER AND BUS WILL NOT OPERATE CORRECTLY.</p> <p>WHEN READING ANOTHER I2C DEVICE THE FIRST BYTE READ USING THE READBYTE FUNCTION IS ALWAYS THE SLAVE ADDRESS OF THAT DEVICE. THIS MUST BE READ AND DISCARDED BEFORE THE REAL DATA CAN BE READ. DO NOT COUNT THIS EXTRA READ WHEN CONSIDERING WHETHER OR NOT TO ACKNOWLEDGE.</p> <p>Should a time-out occur then an error code 8005H is returned, otherwise the data is returned. Readbyte is compatible with both master read and slave read modes.</p>
<b>sendstop</b>	
<i>Function specification</i>	Int sendstop ( )
<i>Parameters returned</i>	ErrCode. If the transfer time out occurs error code 8002H is returned otherwise the status is returned.
<i>Prerequisites</i>	Adapter must be configured using <b>setup</b> . Should normally only be used at the end of transmission. Correct acknowledge sequence must have been applied if the transmission was a read.
<i>Functional description</i>	Instruct the adapter to send a stop code and wait for it to be sent. Should a time-out occur during the sending of a stop then an error code 8002H is returned, otherwise the status is returned.
<b>restart</b>	
<i>Function specification</i>	Int restart (int slaveaddress, int setnack)
	Slaveaddress is the address to be accessed via the I2C, e.g. A1H
	Setnack 1 for no acknowledge 0 for acknowledge – see Functional Description.
<i>Parameters returned</i>	ErrCode. If the transfer time out occurs error code 8003H is returned otherwise the status is returned.
<i>Prerequisites</i>	Adapter must be configured using <b>setup</b> . A start and slave address must have previously been sent using <b>sendaddress</b> . Usually a data pointer would already have been written using writebyte.
<i>Functional description</i>	<p>Sends a start code and the slave address specified and presets the acknowledge status depending on the value of setnack. The acknowledge is set ready for the data transfer after the address and hence in read mode (odd address being sent) if only one byte is to be read the setnack parameter must equal 1. If more than one byte is to be read or if in write mode (even address being sent) then setnack must equal 0.</p> <p>The function waits for the address to be sent. Should a time-out occur during the sending of an address then an error code 8003H is returned, otherwise the status is returned.</p>

## getstatus

*Function specification:* Int getstatus ( )  
*Parameters returned* I<sup>2</sup>Cstatus, the current value of the bus status.  
*Prerequisites* Adapter must be configured using **setup**.  
*Functional description* The function reads status word from the adapter and returns it.

## recover

*Function specification:* Int recover  
*Parameters returned* ErrCode. If the bus recovery failed error code 8006H is returned otherwise the status is returned.  
*Prerequisites* Adapter must be configured using **setup**.  
*Functional description* This function issues two consecutive stop commands on the bus, with a delay in between. It then clears the adapter registers and reads the status. This should normally set the adapter into a known idle state when a bus error or other problem has occurred.  
  
If the status does not indicate bus free or the Bus Error bit is still set then 8006H is returned otherwise the status is returned.

## sendbytes

*Function specification* Int sendbytes (int far \*transferarray)

The far pointer must point to a single dimensional array the format of which is detailed below. The calling function must have initialised elements 0, 1 and 2 prior to calling the function.

Element no	Element name	Description
0	slaveaddress	Slaveaddress is the address to be accessed via the I <sup>2</sup> C Bus, this is in hexadecimal e.g. A0H.
1	wordaddress	Wordaddress is the offset within the slave to which the first byte of data is to be written, see transmission format for more details.
2	nobytes	The number of bytes (n) to be sent. Min value 1.
3	byte 0	First byte to be sent.
	"	
	"	
	byte n	Last byte to be sent.

*Parameters returned* bsent, the number of bytes actually sent.

*Prerequisites* Adapter must be configured using **setup**. Array elements 0, 1 and 2 must be initialised. Usually elements 3 to n would also be initialised. Array must be pre-defined to a size at least large enough to hold all the parameters and data concerned.

*Transmission format* There are two transmission formats, these are:

- i. start-slaveaddress-byte(s)-stop  
If transmission format i.) is required set the wordaddress to a number greater than FFH.
- ii. start-slaveaddress-wordaddress-byte(s)-stop  
If transmission format ii.) is required set the wordaddress to a number less than or equal to FFH.

*Functional description* The function determines the required transmission format and then sends a start code and the slave address. If transmission format ii) has been selected the wordaddress is sent.  
  
The data bytes are then transmitted sequentially.  
  
Should a time-out occur or the slave not acknowledge a transfer the transmission is terminated by a stop and the number of bytes actually transmitted is returned.

When all the bytes have been transmitted a stop is issued and the total number of bytes is returned.

Sendbytes can only be used in master write mode.

## getbytes

*Function specification* Int getbytes (int far \*transferarray)

The far pointer must point to a single dimensional array the format of which is detailed below.

The calling function must have initialised elements 0, 1 and 2 prior to calling the function.

Element no	Element name	Description
0	Slaveaddress	Slaveaddress is the address to be accessed via the I <sup>2</sup> C Bus, this is in hexadecimal e.g. A0H.
1	Wordaddress	Wordaddress is the offset within the slave to which the first byte of data is to be written, see transmission format for more detail.
2	Nobytes	The number of bytes (n) to be sent. Min value 1.
3	byte 0	First byte read.
	"	
	"	
	byte n	Last byte read.

*Parameters returned* nobytesread, the number of bytes actually read.

*Prerequisites* Adapter must be configured using **setup**. Array elements 0, 1 and 2 must be initialised. Elements 3 to n do not need to be initialised since they are where the read data is returned. Array must be pre-defined to a size at least large enough to hold all the parameters and data concerned.

*Transmission format* If the slaveaddress has the least significant bit set (1) then this forms a read address, if the least significant bit is clear (0) then this forms the write address e.g. A0H is the write address and A1H is the associated read address.

Getbytes supports two transfer formats these being:

- i. start-slavereadaddress-byte(s)-stop  
To select transfer format i.) pass the read address as slave address.  
The wordaddress is not used in this format and is ignored by getbytes.
- ii. start-slavewriteaddress-wordaddress-restart-slavereadaddress-byte(s)-stop  
To select transfer format ii.) pass the write address as slaveaddress.  
In this format the wordaddress must be valid.

Wordaddress is a pointer to the first byte of data to be read.

Nobytestoread is the number of bytes to be read. The minimum value allowable is 1.

*Functional description* The function determines the required transmission transfer format, sends the appropriate sequence of start(s) and slave address(es) and checks for acknowledges where necessary.

If the slave fails to acknowledge then a stop is sent and nobytesread is returned equal to 0.

The first data byte read is the slave read address sent(see readbyte description). This is discarded, it is not returned in the transfer array. The data bytes are then read and stored in the transfer array. At the appropriate point acknowledges are ceased – for the last and the last but one byte to be transferred.

A stop is sent after the last byte has been read. On completion the number of bytes read is returned.

Should a time-out occur the transfer is terminated by a stop and the number of bytes successfully read is returned.

Getbytes can only be used in master read mode.

**slavelastbyte**

*Function specification*

void slavelastbyte( )

*Parameters returned*

none.

*Prerequisites*

Adapter must be configured using **setup**. This function would normally only be called following the end of a transmission in slave write mode – when the adapter is being read as a slave, by another master, *not when writing to a slave using the adapter*.

*Functional description*

This function is used when the adapter is a slave being read by a master elsewhere on the bus – the adapter is in slave write mode. The function must be called immediately after the master indicates the last byte has been read (by not acknowledging that byte) this function is required to clear the I<sup>2</sup>C data lines so that the master can send a stop signal.

## 6. Further Information

The following references may be found useful when using the adapter:

Philips Semiconductors Technical Handbook Book 4 Parts 12a and 12b. These give details of the I<sup>2</sup>C compatible ICs, and the I<sup>2</sup>C Bus specification. The PCF8584P used on the adapter is included in later editions. Where the data sheet and this manual disagree, this manual should always be followed when using the adapter.

Philips Components Data Sheet for PCF8584

Philips Application Note No EIE/AN90001 - Interfacing PCF8584 I<sup>2</sup>C bus controller to 80(C) 51 family micro controllers. This gives some useful code but is not written directly for the PC. Please note - the hardware information on the PCF8584 given in this application note sometimes contradicts the data sheet referenced in 8.2, in general the data sheet is correct; the only exception is that a Stop should be sent as c3 (Hex) - as shown in the application, not 43 (hex) - implied in the data sheet ) see Appendix B of this manual for details of control codes). Where in doubt, follow this manual.

## 7. The Real-Time Bus Monitor

The program REALTIM1.EXE in the MONTOR directory is a completely non-invasive real-time bus monitor which records activity on an I<sup>2</sup>C-bus, post-processes the data and stores the results in an ASCII file. This file can be printed out or examined with a word-processor as required. The monitor can record up to 30,000 operations on the I<sup>2</sup>C-bus.

For the real-time monitor to work correctly it must be run using an 8MHz 286 AT type computer or any faster machine (386/486 are ideal). Also, no TSR programs or background applications must be active while running the monitor.

The monitor program can write quite large data files to disc; it must be copied from the floppy disc supplied onto your hard disc before being executed.

The monitor program has to run very fast and without interruptions in order to accurately record data from the I<sup>2</sup>C-bus. To achieve this it re-vectors the normal BIOS keyboard and clock-tick interrupt routines and uses these for its own purposes. It is essential that the monitor program is exited cleanly – this is achieved by pressing any alphanumeric key on the keyboard while it is monitoring; the monitor program will restore the normal interrupts when it finishes.

### **Do not attempt to run the real-time monitor from any version of Windows**

The following mnemonics are used by the monitor program in the ASCII file which it produces.

SaXX	Start code followed by address, acknowledged.
SnXX	Start code followed by address, not acknowledged.
DaXX	Data byte, acknowledged.
DnXX	Data byte, not acknowledged.
STOP	Stop code.
BUS ERROR	A bus error has occurred. This is non-fatal to the monitor but a small amount of data may have been lost whilst recovery was taking place.

Note: The program REALTIM1 expects the ICA93 adapter to be configured as supplied (i.e. default base address, no interrupts). If this is not the case please refer to Section 3 of the User Manual for details of the correct link positions. The one exception is the bus pull-ups. These may be on or off on the ICA93; bus terminations must be present somewhere on the bus for it to operate. The alternative program, REALTIM2 is identical except it is for an ICA93 configured with an alternative base address of 0x312.

## Appendix A I<sup>2</sup>C Communications Adapter Status Codes

This is an eight bit register, read using the `getstatus` routine. Each individual bit has its own meaning as follows:

### Bit 7 (MSB) - The PIN Bit

The PIN bit "Pending Interrupt Not" is a read-only flag which is used to synchronize serial communication. Each time a serial data transmission is initiated (by `sendaddress` routine or setting STA bit) the PIN will be set (= 1) automatically. After successful transmission of one byte (9 clock pulses, including acknowledge), this bit will be automatically reset (= 0) indicating a complete transmission. When the ENI bit (enable interrupt) is also set, the PIN triggers an external interrupt via the selected IRQ line when PIN is reset. When in receiver mode, the PIN is also reset on completion of each received byte. In polled applications, the PIN bit is tested (using the `getstatus` routine) to determine when a serial transmission has been completed. In receiver mode, the PIN bit is tested (using the `readbyte` function). When the PIN becomes set all other status bits will be reset, with the exception of the BB (not Bus Busy) bit.

In short, when transmitting data, if PIN = 0 then the data has been sent, if PIN = 1 then it has not. When receiving data, if PIN = 0 then there is unread received data ready to read, if PIN = 1 then either the data received has already been read, or no data has yet been received.

### Bit 6 - Not Used

This bit is not currently used and will always = 0.

### Bit 5 - The STS Bit

When in slave-receiver mode (i.e. transmission initiated by a master elsewhere on the I<sup>2</sup>C bus), the flag STS = 1 when an externally generated Stop condition is detected, otherwise STS = 0. This flag is used only in slave-receiver mode.

### Bit 4 - The BER Bit

The BER (Bus Error) bit. BER = 1 when a misplaced Start or Stop has been detected, otherwise BER = 0. This can be quite serious since the I<sup>2</sup>C devices on the bus may be left in an undefined state after a bus error has occurred - in some circumstances the only way to get the bus going again may be to reset all the I<sup>2</sup>C devices on it.

### Bit 3 - The LRB/ADO Bit

The LRB (Last received Bit) / ADO (Address 0 "General Call" Address Received) bit. This dual function status bit holds the value of the last received bit over the I<sup>2</sup>C bus when AAS (Bit 2) = 0. Normally this will be the value of the slave acknowledge; thus checking for slave acknowledgement is done via testing of the LRB bit. When AAS (Bit 2) = 1 ("Addressed As Slave"), the I<sup>2</sup>C Communications Adapter has been addressed as a slave and the ADO bit will = 1 if the slave address received was the "General Call" address. For further information on the "General Call" Address, see the Philips data books referenced in Section 8 of this User Manual.

### Bit 2 - The AAS Bit

The AAS ("Addressed As Slave") bit. When acting as a slave-receiver, this flag is set = 1 when an incoming address over the I<sup>2</sup>C bus matches the value defined by the setup routine, or if the slave address received was the I<sup>2</sup>C bus "General Call" address (00 Hex). In all other circumstances, AAS = 0.

### Bit 1 - The LAB Bit

The LAB (Lost Arbitration) bit. This bit is set = 1 when, in multimaster operation (more than one master present on the I<sup>2</sup>C bus) arbitration is lost to another master on the I<sup>2</sup>C bus. In all other circumstances, LAB = 0.

### Bit 0 - The BB Bit

The BB (not Bus Busy) bit. This is a read-only flag indicating when the I<sup>2</sup>C bus is in use. BB = 0 indicates that the bus is busy, and access is not possible (unless of course it is busy because the I<sup>2</sup>C Communications Adapter itself has control of the bus). This bit is set = 1 by Stop conditions and reset = 0 by Start conditions. In short, BB = 1 means that the bus is free and a new transmission can be started.



## Appendix B – I<sup>2</sup>C Communications Adapter Control Codes

The Control Register should normally be written using the setup, sendaddress and sendstop routines. To implement more advanced functions such as enabling hardware interrupt generation or implementing long distance mode, these routines may need to be modified or the users own routines used in their place.

The Control Register is accessed by writing to I/O address:

1+Base address of card (set by links on board).

The Data Register is accessed by writing to I/O address:

Base address of card (set by links on board).

E.g. in C, `outp(0x311, 0xc3)`; would cause an I<sup>2</sup>C Communications Adapter with base address = 0x310 to generate a Stop condition on the I<sup>2</sup>C bus. For detailed information on these codes, the Philips data sheet on the PCF8584 device (see Section 8, Further Information)

0x00 read/write own address register (followed by a data byte to the data register).

0x20 read/write clock register (followed by a data byte to the data register).

After either of the above operations, 0x41 must be written to the control register to re-enable the I<sup>2</sup>C interface.

0xc3 send a Stop signal over the I<sup>2</sup>C bus.

0x41 I<sup>2</sup>C NOP (no operation) instruction, acknowledge enabled.  
(Use 0x41 and 0x40 to turn on and off acknowledge)

0x45 (While bus is free) - Send Start & slave address, acknowledge enabled. The address to be sent must have first been written to the data register before sending the startcode.

0x45 (While already master on the bus) - Send Repeated Start & slave address (Restart). The address to be sent is placed in the data register after sending the start code.

0x47 send Stop, Start, slave address (i.e. restart transmission without releasing control of the I<sup>2</sup>C bus). The address to be sent is placed in the data register after sending the start code.

To execute the last four instructions with acknowledge disabled, i.e. negative acknowledge - nack, set; send the control code-1, e.g. 0x40, 0x44, 0x46.

## Appendix C - The Most Commonly Asked I<sup>2</sup>C Questions

### General Questions

**Question Will my adapter work in a Pentium PC?**

Answer Yes and there is no need to alter LK 4 from the position in which your adapter was shipped.

**Question Will my adapter run I2C clock speeds greater than 90KHz?**

Answer At the moment your adapter is limited by the Bus Controller chip fitted, to a maximum of 90KHz as a master and 100KHz as a slave.

**Question Will my adapter work under Windows NT4\* or Windows 95\*?**

Answer The adapter will work under both these systems without problems, but the software supplied with the adapter is 16 bit only. Windows NT and Windows 95 DLLs are available please contact our sales team for further information.

**The bus monitors are best run from DOS (not Windows DOS Shell) as this minimises the risk of missing part of a transfer.**

\* All trade marks acknowledged

**Question How can I find out if the adapter is clashing with another card in my PC?**

Answer If your adapter is located at a base address of 310H (as shipped) then run the bus monitor (REALTIM1) application supplied following the instructions in the adapter manual. With no activity on the bus the monitor should display a fix 'A', stop the monitor and edit the file produced if the file states that the bus was free and the status was 81H then your adapter is indeed located at 310H and there are no clashes within the PC.

**If your adapter is at 312H then repeat the above using the REALTIM2 bus monitor.**

**Question I get corrupted transfers why is this?**

Answer The most likely reason for corrupted transfers is either incorrect bus termination or excessive capacitance - see the manual for details.

**Question Do you have software to talk to my.....?**

Answer Unfortunately there are too many I2C devices for us to be able to offer complete solutions - although we can supply a windows based application called WINI2C which is designed for those just starting I2C or wishing to perform simple I2C tasks, please contact our sales team or look on our web site, [www.calibreuk.com](http://www.calibreuk.com) for further information.

**Question I am trying to read from a device, the first time my software works fine but when I try again I can't get anything what's wrong?**

Answer Please check that you are changing the value of Setnack in accordance with the manual, it is likely that you have not made Setnack 1 for the last **AND** last but one bytes being read.

### DOS Software Questions

**Question My I2C adapter locks up with a constant status - why?**

Answer If you are using either the 'C' or Basic library functions supplied with the adapter on a fast PC it is possible that the PC is polling the status register too quickly, the simplest way to prevent this is to add a small delay prior to reading the status in the getstatus routine. Alternatively use the windows DLL supplied as these automatically allow for speed of the PC at run-time.

### Windows 95 and NT Questions

**Question My software cannot find the adapter. Your Windows software reports that it cannot configure the adapter. Why is this?**

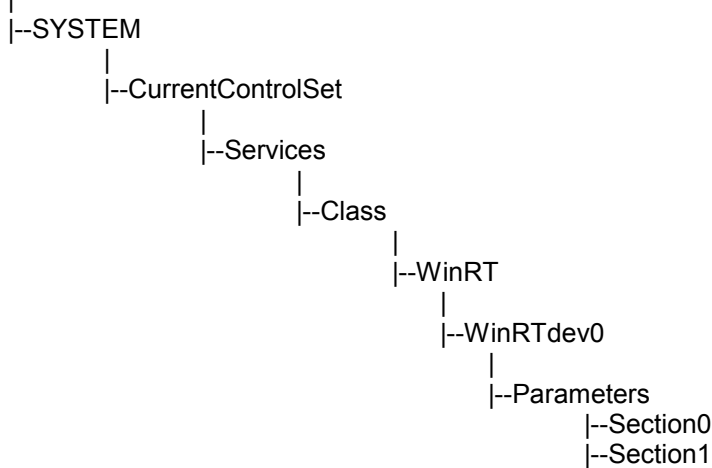
Answer Have you registered the device driver as detailed in the software manual? If so check that the address links (see adapter manual for details) are correct for the location at which you registered the driver.

**Question I think I have registered the driver how can I find out if I have?**

Answer You need to inspect the registry as follows

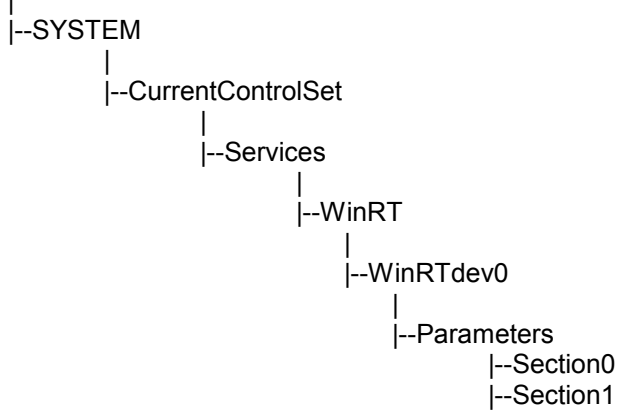
Windows 95 START - Run regedit

HKEY\_LOCAL\_MACHINE



Windows NT START - Run regedit

HKEY\_LOCAL\_MACHINE



**Question** I am using your Windows 95 / NT DLL and I am always getting a time out error code. Why?

**Answer** Check the Syntax of the setup function, swapping the Status Wait and Sclk parameters most usually causes this problem.  
The correct syntax is i2cstatus = setup (baseaddress, ownaddress, sclk, statuswait)

**Question** I have read the manual and still cannot get the communications to run. What do I do next?

**Answer** Check that you have fully implemented the protocol between the adapter and the other I2C devices see the device manufacturers data sheet for details.

Check that the software you have written is logically and syntactically correct - this is probably the most common cause of software faults we have to deal with.

Send us the following details:-

- 1) The link settings of the adapter.
- 2) A sketch of the relevant I2C hardware including the location of bus termination.
- 3) The type and speed of processor within your PC and which operating system, you are running.
- 4) Brief software listings, or which Calibre software you are running.
- 5) The serial number of your I2C adapter, or when you purchased it.

PLEASE EMAIL YOUR QUERY TO: [techsupport@calibreuk.com](mailto:techsupport@calibreuk.com)

OR FAX YOUR QUERY TO: 44-1274-730960

We will endeavour to help you.