



**Future Technology Devices International Ltd.**

## **Application Note**

# **AN\_173 Establishing FT1248 Communications using a Morph-IC-II**

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The Morph-IC-II module is an FPGA-USB development platform that can be programmed to support a number of serial communications interfaces including FT1248 and Synchronous 245 FIFO. A number of supporting source code samples have been provided by FTDI to assist in the development of Morph-IC-II applications. One of these is an FT1248 application. This application note contains the HDL to synthesise the Master FT1248 and two terminals used to control the hardware and transfer data.

This application note gives a step-by-step guide in how to establish an FT1248 demonstration application.

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**Future Technology Devices International Limited (FTDI)**

Unit 1, 2 Seaward Place, Glasgow G41 1HH, United Kingdom  
Tel.: +44 (0) 141 429 2777 Fax: + 44 (0) 141 429 2758  
E-Mail (Support): [support1@ftdichip.com](mailto:support1@ftdichip.com) Web: <http://www.ftdichip.com>

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## 1 Introduction

The “MorphIC\_FT1248\_master” zip-file gives an example FT1248 application with example software to control the interface. This application contains the necessary HDL source files to establish two interfaces: an FT1248 communications interface between an FTDI UM232H and the FPGA of an FTDI Morph-IC-II, as well as a Synchronous 245 FIFO interface between the FPGA and FT2232H of the Morph-IC-II.

The aim of this application note is to give a guide to evaluating the FT1248 interface.

The application source code can be downloaded from  
[http://www.ftdichip.com/Products/Files/MorphIC\\_FT1248\\_master.zip](http://www.ftdichip.com/Products/Files/MorphIC_FT1248_master.zip)

The following apparatus is used in this application example:

- 1 x FTDI Morph-IC-II – A USB-FPGA development module
- 1 x FTDI UM232H – A Hi-Speed USB to Serial/FIFO Module
- A proto-typing setup used to connect the UM232H to the Morph-IC-II
- 1x USB Type-A cable and 1 x USB Type-B cable
- FT1248 application project files – The HDL collateral supplied for this application
- FT\_Prog – A Programming Utility for FTDI devices
- MorphLd-II – Programming utility for the Morph-IC-II (included in download)
- Quartus-II – An Altera HDL Tool-Chain for use with Altera FPGAs
- FT1248 Controller – An FTDI utility used from controlling FT1248 data transfers (included in download)
- Terminal.x – An FTDI utility for transferring data over different interfaces (included in download)

See Appendix B for links.

On completion of reading this app note the reader should be able to:

- Configure a FT2232H device for synchronous 245 FIFO mode
- Configure a FT232H device for synchronous FT1248 mode
- Program an Altera based FPGA to bridge an FT1248 device to a synchronous 245 FIFO device

### 1.1 What is a UM232H Module?

A UM232H is the evaluation board for the FT232H. This module provides access to the serial/FIFO data channel. This module may be used to convert one USB port to either: UART, Synchronous 245 FIFO, Asynchronous 245 FIFO, FT1248, JTAG, I<sup>2</sup>C and SPI.

For more information on the modules please see:

#### **UM232H**

[http://www.ftdichip.com/Support/Documents/DataSheets/Modules/DS\\_UM232H.pdf](http://www.ftdichip.com/Support/Documents/DataSheets/Modules/DS_UM232H.pdf)

#### **FT232H Datasheet**

[http://www.ftdichip.com/Support/Documents/DataSheets/ICs/DS\\_FT232H.pdf](http://www.ftdichip.com/Support/Documents/DataSheets/ICs/DS_FT232H.pdf)

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## 1.2 What is Morph-IC-II?

Morph-IC-II is a USB-FPGA development platform. The major components of this module are the FT2232H and an Altera Cyclone II FPGA.

The FT2232H is a USB communications device which converts USB data into a range of different interfaces including UART, Synchronous 245 FIFO, Asynchronous 245 FIFO and more. The FT2232H provides one programming channel for the FPGA (passive serial) and one application data channel to access data after configuration of the FPGA. Passive serial is an interface widely used by Altera FPGAs for programming and configuration. This interface is supported by the FT2232H's MPSSE (Multi-Protocol Synchronous Serial Engine).

For additional information please refer to the following documentation:

### Morph-IC-II Datasheet

[http://www.ftdichip.com/Support/Documents/DataSheets/Modules/DS\\_Morph-IC-II.pdf](http://www.ftdichip.com/Support/Documents/DataSheets/Modules/DS_Morph-IC-II.pdf)

### MorphLd and MorphIO-II Utilities for Morph-IC-II

[http://www.ftdichip.com/Support/Documents/AppNotes/AN\\_141\\_MorphIO-II%20and%20MorphLd%20Utilities%20for%20Morph-IC-II.pdf](http://www.ftdichip.com/Support/Documents/AppNotes/AN_141_MorphIO-II%20and%20MorphLd%20Utilities%20for%20Morph-IC-II.pdf)

## 1.3 What is Synchronous 245 FIFO?

Synchronous 245 FIFO is a half-duplex point-to-point communications interface. This interface is synchronised to transmit data at 60MHz. Synchronous 245 FIFO contains all the signals used by Asynchronous 245 FIFO plus an additional 2 lines: clock out which is a 60MHz clock signal and output enable used to enable the data bus outputs of a slave device.

Synchronous FIFO can transfer data at much higher data rates than Asynchronous FIFO. Synchronous 245 FIFO requires the master and the slave devices to be synchronised to the same 60MHz clock. Using this application note and the supporting hardware and application files, establishing a successful Synchronous 245 communication link can be made easy.

For additional information please see:

### AN\_130 FT2232H Used In An FT245 Style Synchronous FIFO Mode

[http://www.ftdichip.com/Support/Documents/AppNotes/AN\\_130\\_FT2232H\\_Used\\_In\\_FT245%20Synchronous%20FIFO%20Mode.pdf](http://www.ftdichip.com/Support/Documents/AppNotes/AN_130_FT2232H_Used_In_FT245%20Synchronous%20FIFO%20Mode.pdf)

### DS\_FT2232H

[http://www.ftdichip.com/Support/Documents/DataSheets/Modules/DS\\_FT2232H\\_Mini\\_Module.pdf](http://www.ftdichip.com/Support/Documents/DataSheets/Modules/DS_FT2232H_Mini_Module.pdf)

### AN\_165\_Establishing\_Synchronous\_245\_FIFO\_Communications\_using\_a\_Morph-IC-II

## 1.4 What is FT1248?

FT1248 is a synchronous half duplex interface pioneered by FTDI. FT1248 is a similar interface to SPI, but with eight data lines labelled MIOSIO 0 to 7. These lines can be used to transfer parallel data in both directions. The MISO line can be designated to be used for indicating the status of the slave in parallel with the data being transferred.

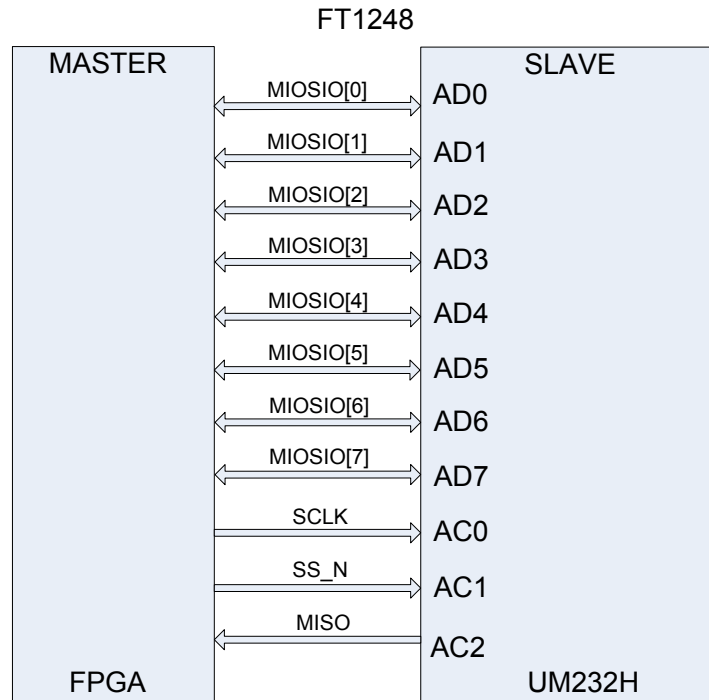
FT1248 can be configured to operate in different modes, the clock polarity, number of parallel bits transferred, the serial bit order and flow control can be varied. Varying the number of parallel bits being transferred or bus width, changes the maximum rate of data transfer. The bus width modes are 1-bit wide mode, 2-bit wide mode, 4-bit wide mode and 8-bit wide mode. 1-bit wide mode uses only one of the MIOSIO data line to transfer data. 2-bit wide mode, 4-bit wide mode and 8-bit wide mode used 2, 4 and 8 MIOSIO data lines respectively to transfer data in parallel.

The FT232H contains a slave FT1248 to USB interface that can be selected for use by an external EEPROM. This interface requires an input clock signal sourced from a master device, the frequency of the clock can be up to 30MHz.

## 2 Interfaces used in this Application

In this application two different interfaces are used to transfer data. FT1248 transfers data to and from the FT232H of the UM232H and the FPGA of the Morph-IC-II. Synchronous 245 FIFO transfers data to and from the FPGA of the Morph-IC-II and the FT2232H of the Morph-IC-II.

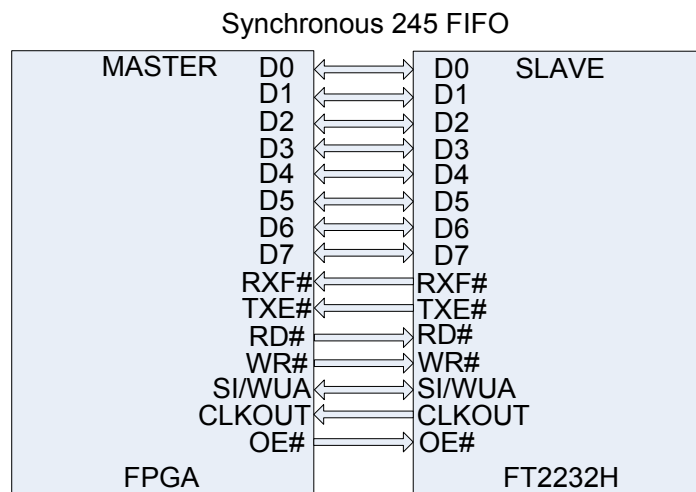
### 2.1 FT1248 Signal Flow



**Figure 1 – FT1248 Interface**

The data lines and signal flow direction of the FT1248 interface used to transfer data between the UM232H and the Morph-IC-II are shown in Figure 1.

### 2.2 Synchronous 245 FIFO Signal Flow



**Figure 2 – Synchronous 245 FIFO Data Flow Directions**

The data lines and signal flow directions of the Synchronous 245 data interface used to transfer data between the FPGA and the FT2232H of Morph-IC-II are shown in Figure 2.

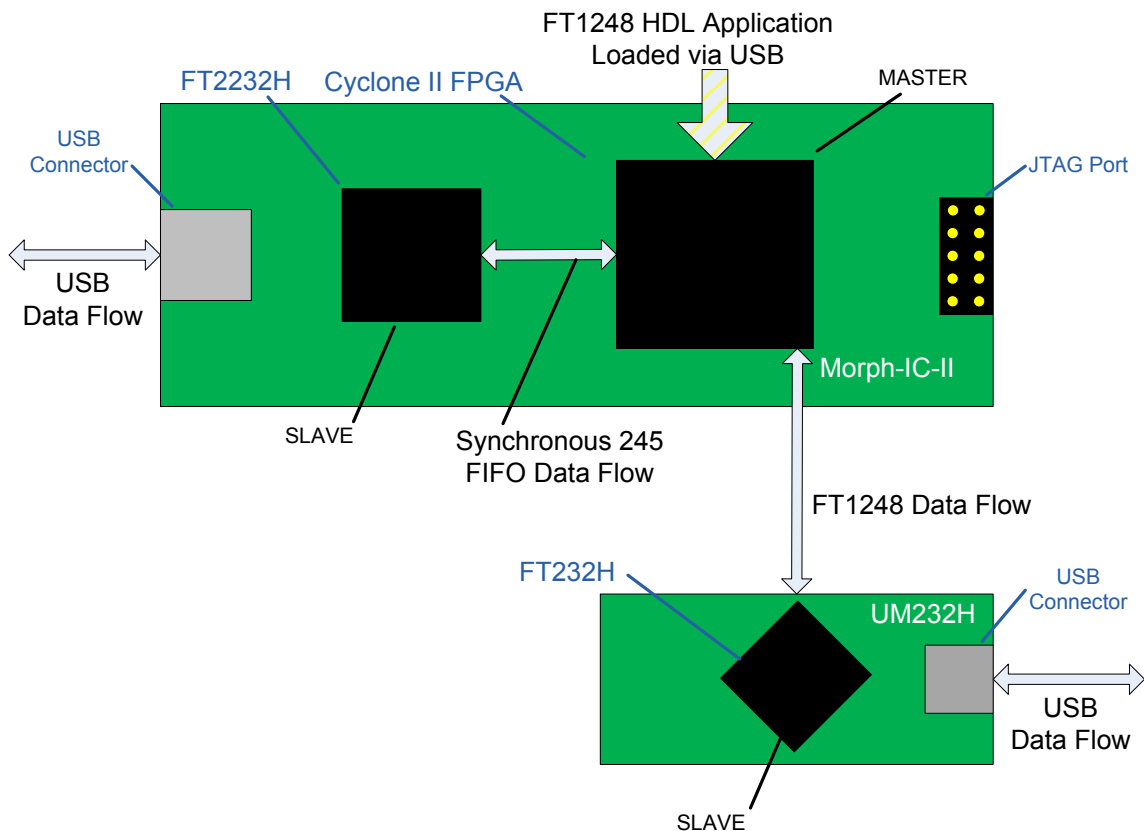
### 3 Example FT1248 FIFO Application

Included in the Morph-IC-II download is a Quartus-II Archive File labelled "MorphIC\_HS\_FT1248.qpf". Contained in this file is a collection of RTL files used to construct the hardware that establishes a master synchronous 245 device that controls communication between two synchronous 245 slave devices. Also contained in this archive folder is a Quartus-II project folder that is ready to compile. This project file configures all the device settings, the pin-map and calls for a RBF file containing the entire project to be outputted after the project compiles. This RBF file can be loaded to the Morph-IC-II to synthesize the FT1248 application hardware in the FPGA.

Links for all the necessary utilities and applications are given in Appendix B.

#### 3.1 An Outline of the FT1248 Application

An outline of the FT1248 application is illustrated in Figure 3. This diagram illustrates the components used and their functions.



**Figure 3 : A Block Diagram of the FT1248 FIFO Application**

The FT1248 application is first loaded into the FPGA via USB. The application HDL creates a master FT1248 to Synchronous 245 FIFO device. When the master device is synthesised, FT1248 data can be transferred from the FT232H to the FPGA of the Morph-IC-II then translated into Synchronous 245 and transferred to the FT2232H.

## 3.2 RTL Code

The following code sample lists the ports of the Synchronous 245 Interface application which is available in the "MorphIC\_FT1248\_master" download. These ports include a reset line, the synchronous 245 FIFO data interface of the on board FT2232H of the Morph-IC-II and an FT1248 data interface of UM232H.

```
ENTITY MorphIC_HS_FT1248 IS
  PORT (-- Inputs
    clk50      : in  std_logic;      -- 50MHz clock input unused
    reset     : in  std_logic;      -- Active low reset via BD7

  -- Morphic on board FT2232H signals
    mdata      : inout std_logic_vector(7 downto 0);  -- Port A Data Bus
    mrxfn      : in  std_logic;
    mt xen     : in  std_logic;
    mrdn       : out std_logic;
    mwrn       : out std_logic;
  --   moen     : out std_logic;
  --   old_clock : in  std_logic;      -- unused
    msndimm    : out std_logic;      -- unused
  --   mclk60   : in  std_logic;

  -- High speed Synchronous 245 signals
    acbus9     : in  std_logic;      -- unused
    acbus8     : in  std_logic;      -- unused
    acbus6     : in  std_logic;      -- unused
    acbus5     : in  std_logic;      -- unused
    acbus4     : in  std_logic;      -- unused
    acbus3     : in  std_logic;      -- unused
    hdata      : inout std_logic_vector(7 downto 0);
    sclk       : out std_logic;      -- SCLK
    ss_n       : out std_logic;      -- select #
    miso       : in  std_logic;      -- miso
  );
END MorphIC_HS_FT1248;
```

The following VHDL files are included in the Quartus-II project for this application:

### **FT1248\_master.vhd**

- Used to access FT232H chip via the FT1248 bus

### **upcntg.vhd**

- A generic n bit up counter with async and sync resets.

### **syncflop.vhd**

- This syncs signals from different clock domain

### **MorphIC\_HS\_FT1248.vhd**

- FT1248 master interface between FT232H and FT2232H device

### **FT1248\_master\_cont\_cont.vhd**

- This will control the FT1248\_master block by decoding a wrapper from the host PC.

### **dncntlg.vhd**

- This is a generic n bit down counter with async and sync resets and load

The name of the Quartus-II project is MorphIC\_HS\_FT1248.qpf

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### 3.3 Reset Polarity

When programming the Morph-IC-II with the default USB-to-FPGA utilities an active high reset needs to be used. When programming the Morph-IC-II over JTAG an active low reset should be used.

For programming over USB, set the HDL as follows:

```
MorphIC_HS_FT1248.vhd-  
146 --reset_n <= reset; -- polarity to programme over JTAG  
147 reset_n <= not reset; -- polarity to programme over USB
```

Note: This is the default setting.

For programming over JTAG, set the HDL as follows:

```
MorphIC_HS_FT1248.vhd-  
146 reset_n <= reset; -- polarity to programme over JTAG  
146 --reset_n <= not reset; -- polarity to programme over USB
```

Note: Programming over JTAG is not covered in this application note.



## 4 Example Application Procedure

In this section a step by step guide is given for establishing FT1248 communications between a Morph-IC-II and a UM232H. This guide covers the following processes:

- Configuring the EEPROM of the UM232H
- Connecting the Mini-Module to the Morph-IC-II
- Compiling the Quartus-II project and editing the Pin-Map of the application
- Loading the application to the FPGA
- Verification of FT1248 communications

### 4.1 Configuring the EEPROM of the UM232H

The EEPROM of the UM232H is set to UART mode by default. To establish FT1248 communications the Serial/FIFO port needs to be configured into FT1248 mode by setting the parameters as shown in **bold** in the table below. The default EEPROM configuration of the FT232H on the Morph-IC-II is suitable for this FT1248 application.

It is important to note the FT1248 settings defined by the EEPROM must match the application. There are three options, Clock Polarity High, Bit Order LSB and Flow Ctrl not selected.

Parameter	Value	Notes
USB Vendor ID (VID)	0403h	FTDI default VID (hex)
USB Product ID (PID)	6014h	FTDI default PID (hex)
bcd Device	009h	
Pull down I/O Pins in USB Suspend	Disabled	Enabling this option will make the device pull down on the UART interface lines when in USB suspend mode (PWREN# is high).
Manufacturer Name	FTDI	
Max Bus Power Current	150mA	
Power Source	Bus Powered	
Device Type	FT232H	
USB Version	0200	Returns USB 2.0 device description to the host. Note: The device is a USB 2.0 Full Speed device (12Mb/s) as opposed to a USB 2.0 Hi-Speed device (480Mb/s).
Remote Wake Up	Enabled	Taking RI# low will wake up the USB host controller from suspend in approximately 20 ms.
High Current I/Os	Disabled	Enables the high drive level on the UART and ACBUS I/O pins.
Load VCP Driver	Enabled	Makes the device load the VCP driver interface for the device.
Hardware Specific Port A	<b>FT1248 Mode</b>	Select FT1248 mode to communicate in FT1248 signals through Port A.
Driver	<b>D2XX Direct</b>	Suppresses VCP driver
FT1248 Options: CPOL High Bit Order LSB Flow Ctrl	<b>Must Match FT1248 Controller</b>	FT1248 Options define: clock polarity, bit order and flow control. This EEPROM configuration must match the configuration set in the FT1248 Controller before the ports are opened to allow for communications.

**Table 1 – Recommended EEPROM Configuration**

For a detailed guide in how to program the EEPROM:

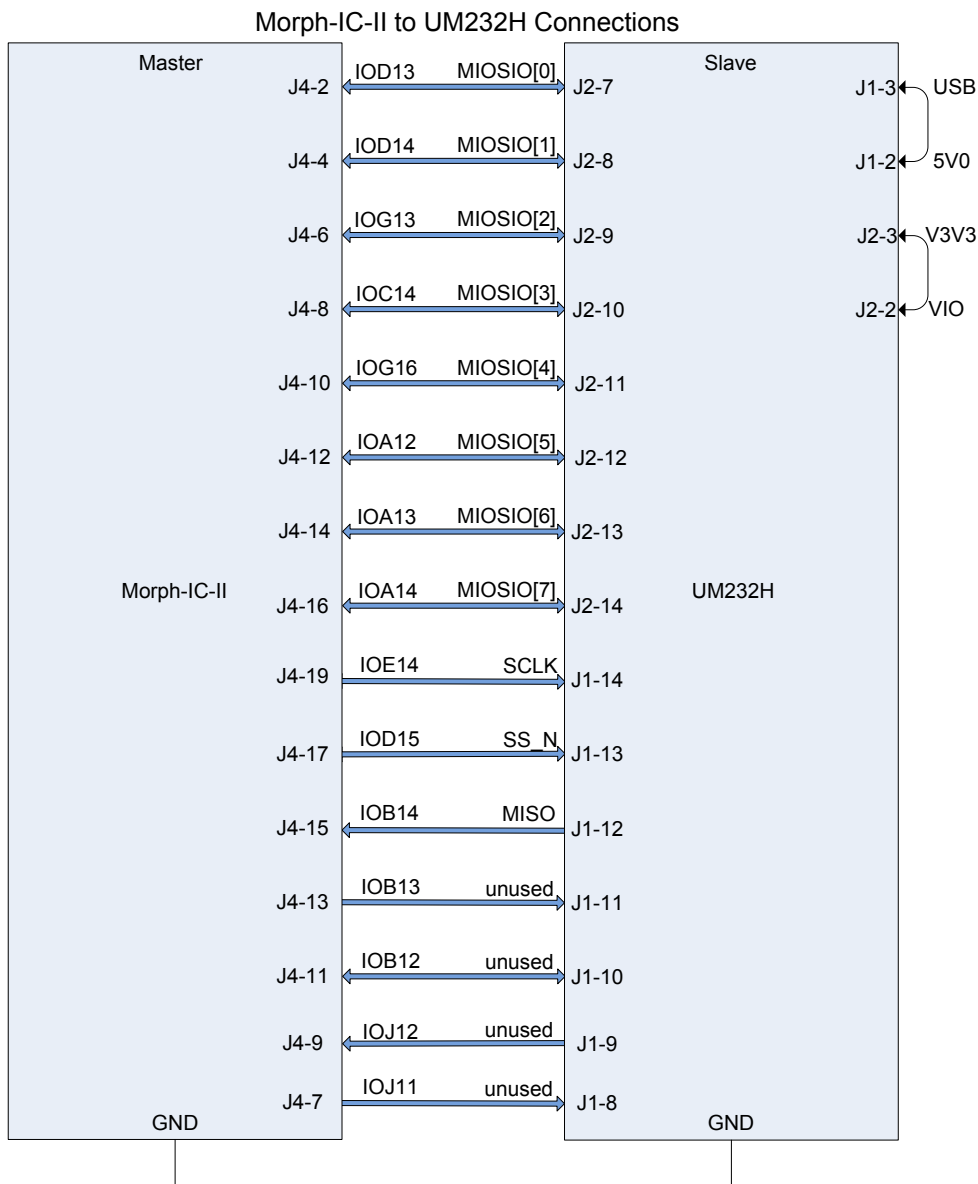
**FT\_PROG User Guide:**

[http://www.ftdichip.com/Support/Documents/AppNotes/AN\\_124\\_User\\_Guide\\_For\\_FT\\_PROG.pdf](http://www.ftdichip.com/Support/Documents/AppNotes/AN_124_User_Guide_For_FT_PROG.pdf)

## 4.2 Connecting the Morph-IC-II and UM232H

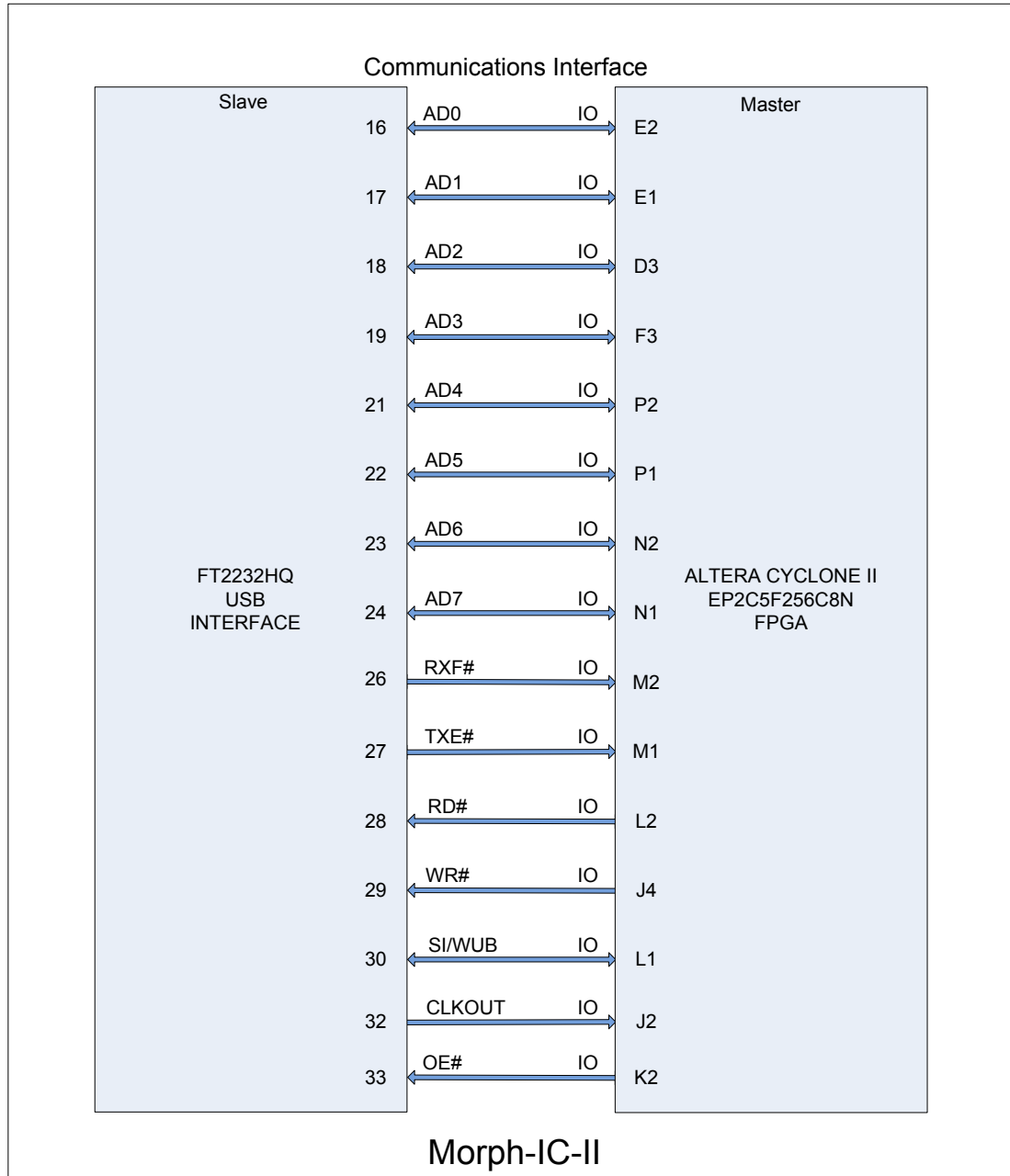
In order to establish communications between a UM232H and a Morph-IC-II, both devices need to be correctly connected to each other as shown in Figure 4 where the pin labels and pin designators of each connected pin are given. The pins of the Morph-IC-II can be relocated since they are all general purpose I/O pins, the Morph-IC-II pin locations illustrated here are chosen to be in a simple location and they all correlate with the pin-map in the Quartus-II project supplied for this application.

It should be noted that in the UM232H VBUS is connected to VCC to power the chip and V3V3 is connected to VIO to allow the IOs of the FT232H can be powered; these connections are illustrated in Figure 4.



**Figure 4 – Morph-IC-II and FT232H wire scheme**

The basic wire configuration of the Morph-IC-II is illustrated in Figure 4. The connections for the FT2232H and the FPGA are shown in Figure 5. These connections are defined by the Morph-IC-II PCB and cannot be changed for this application.



**Figure 5 – Communications between the Hi-Speed USB Device of the Morph-IC-II and the FPGA of the Morph-IC-II**

## 4.3 Editing the Quartus Project

The FT1248 application contains a Quartus II archive file containing all the source code and compiling parameters. A pre-compiled RBF is also included thus the Quartus II software package is not required for this project, however if any editing is required, the archived project file can be opened and edited using Quartus II.

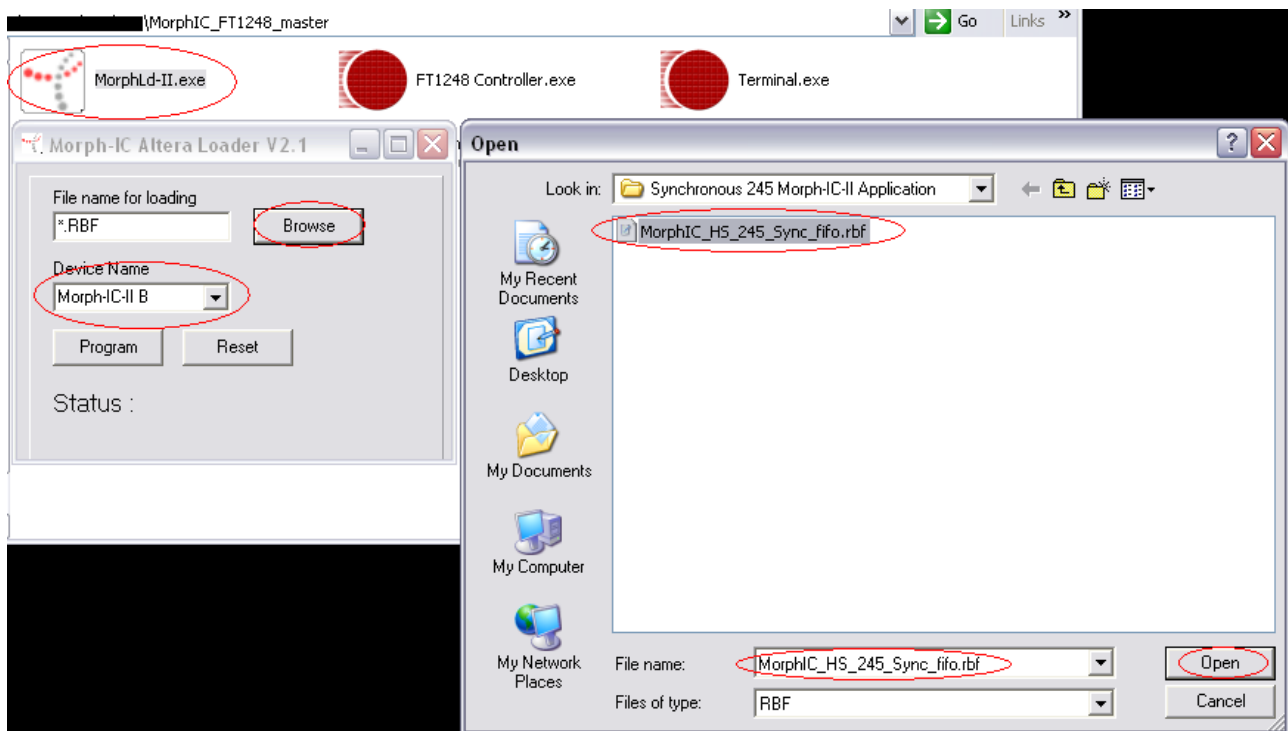
For Quartus II download and support, please refer to [www.altera.com](http://www.altera.com)

## 4.4 Load RBF

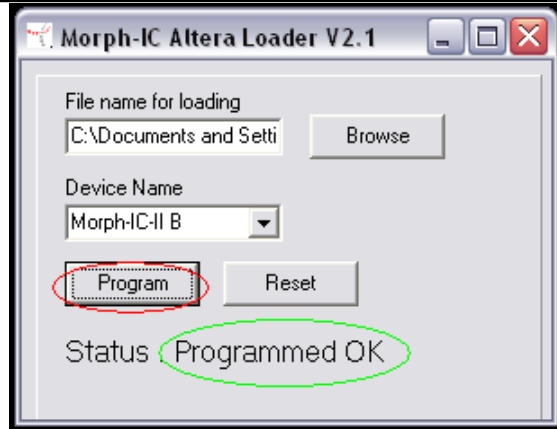
This section will describe how an application is programmed onto the Morph-IC-II. The Morph-IC-II uses a Raw Binary File (\*.RBF) as a standard format. Included in the Morph-IC-II Applications and Utilities database is a utility called MorphLd-II.exe.

To load the featured FT1248 application to the Morph-IC-II; open the MorphLd-II utility and select Morph-IC-II B as the subject device port. The next step is to click on the Browse button inside the MorphLd-II panel, then navigate to the "MorphIC\_HS\_FT1248\_restored" directory and open the file "MorphIC\_HS\_FT1248.rbf" as illustrated in Figure 6.

With the suitable RBF file and subject device port selected the Morph-IC-II can be programmed by clicking "Program" as shown Figure 7.



**Figure 6 – Opening the MorphLd-II Utility**

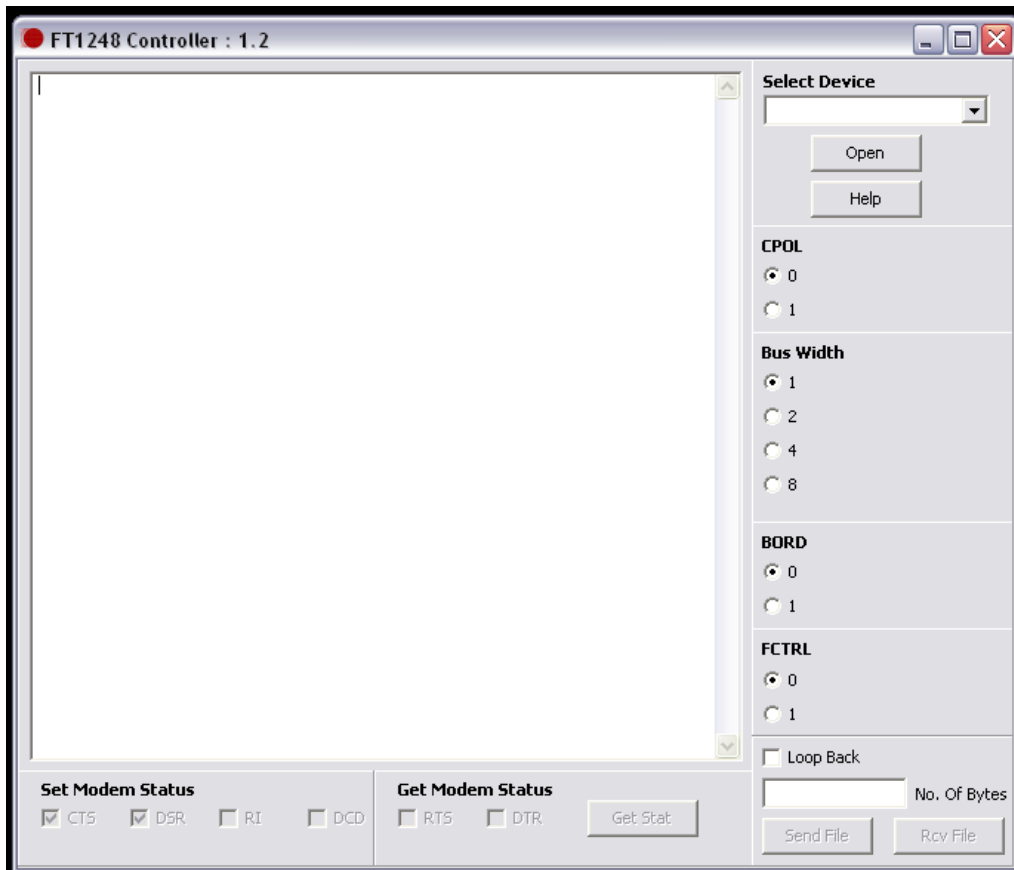


**Figure 7 – Program the Morph-IC-II**

## 4.5 Test for communications

FT1248 can be configured in a number of different ways, the clock polarity, bus width, bit-order and flow control can change. The utility FT1248 Controller which is used to control communication between the FT1248 and Morph-IC-II can be configured to communicate in all FT1248 formats; however this program does not configure the EEPROM. Noting this, it is important that the FT1248 Controller's settings match the FT1248 options set in the EEPROM. The FT1248 Controller is shown in Figure 8. The FT1248 options are as follows: CPOL defines the clock polarity, Bus Width defines the number of parallel bits being transferred, BORD defines the bit order where 0 sets the MSB to be first, FCTRL determines if flow control is enabled or disabled.

**N.B.** To avoid the FT1248 from becoming non-responsive, the correct configuration needs to be selected before the Morph-IC-II A port is opened. If the procedure is not followed correctly the utility may halt, if this happens: reset the Morph-IC-II, reprogram the Morph-IC-II and restart the verification.



**Figure 8 – FT1248 Controller**

### 4.5.1 Verification Procedure

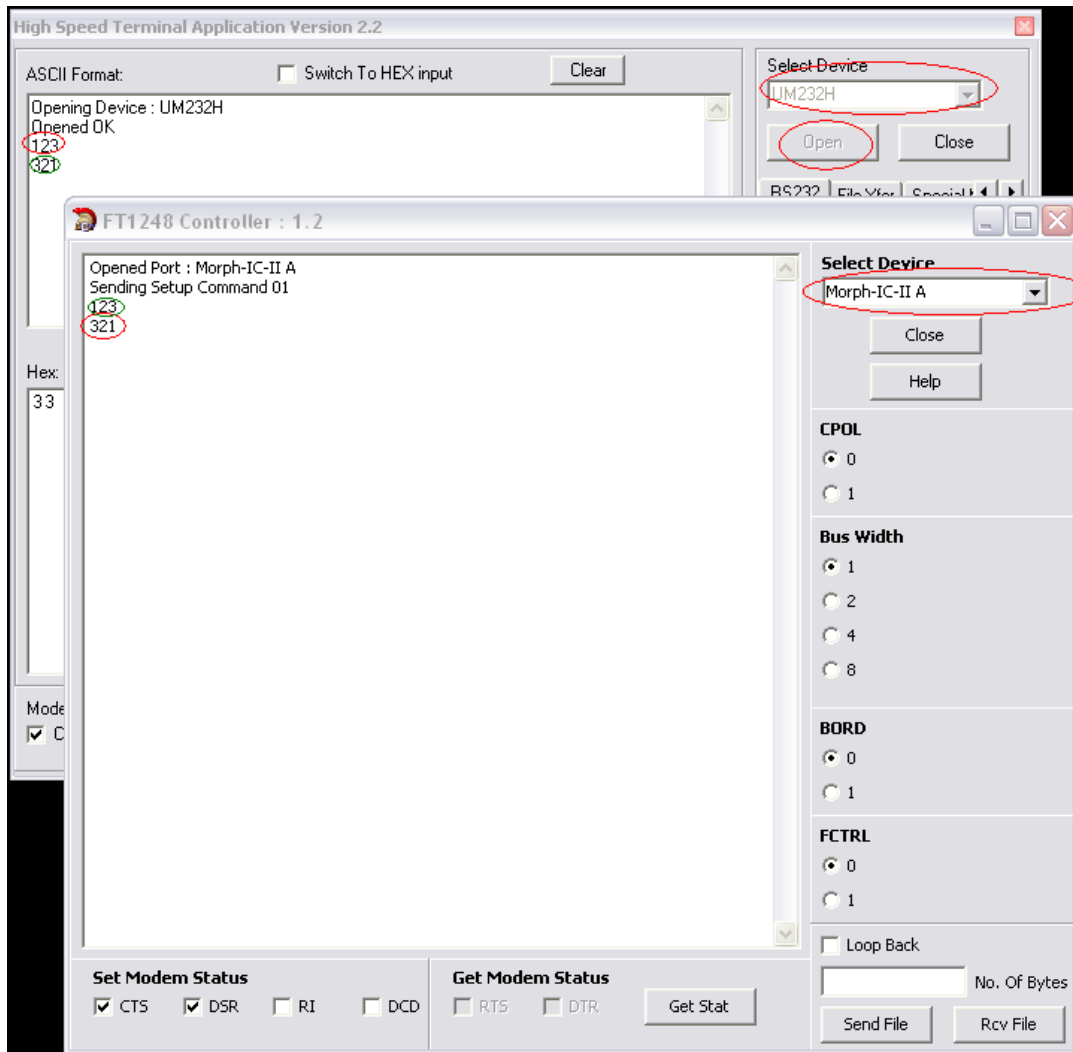
Two utilities are supplied as part of the FT1248 application download; these utilities are used to control and monitor FT1248 communications between the UM232H and Morph-IC-II. The utility "FT1248 Controller" is used to display and control data transferred via the Morph-IC-II port A and the utility "terminal.exe" is used to display and control data transferred via the UM232H port. The icons for these utilities are illustrated in Figure 9.



**Figure 9 – Verification Utilities**

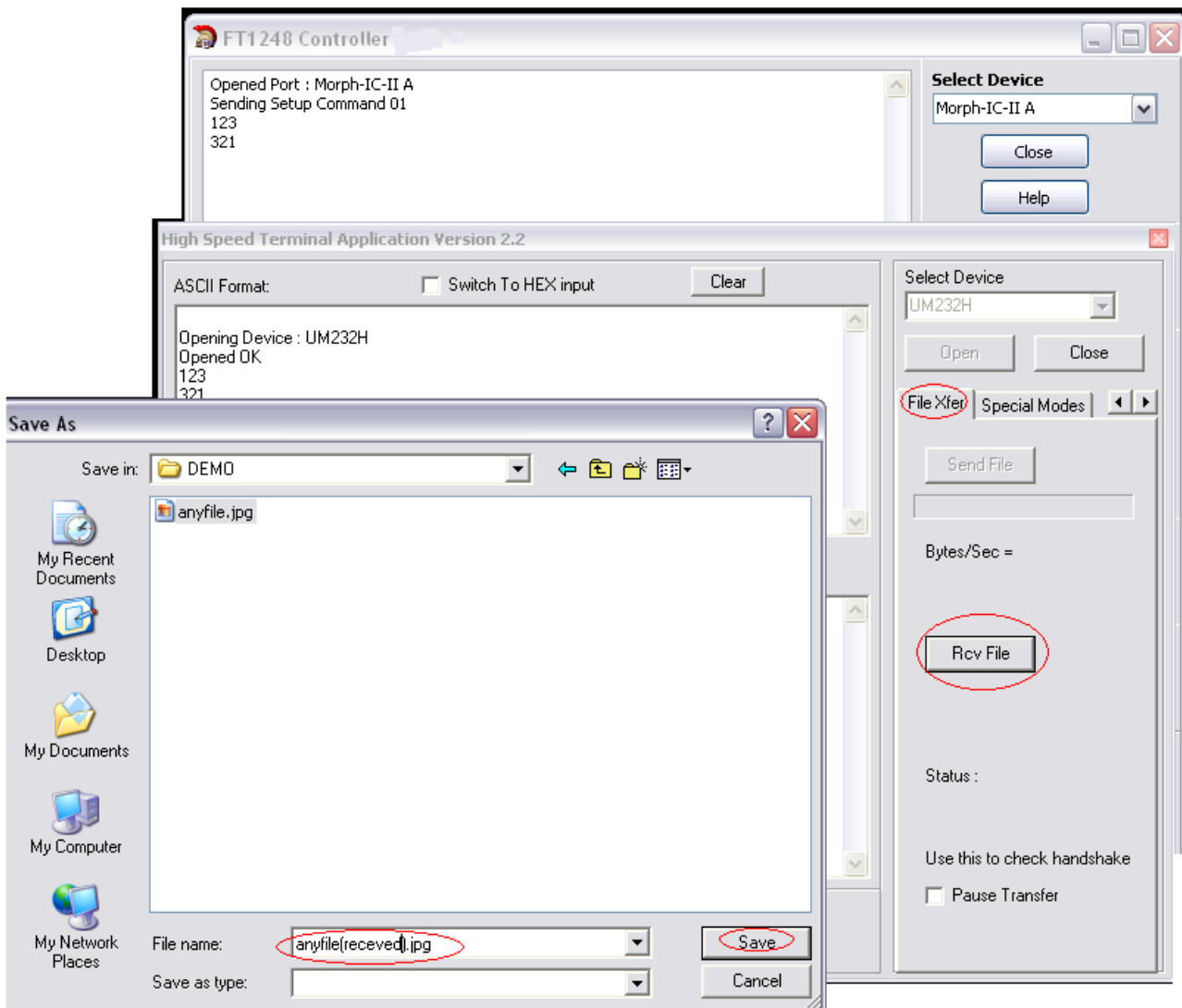
After opening the two utilities, select the FT1248 mode in the FT1248 controller, then select the device each utility should control. The Terminal.exe utility opens the UM232H and the FT1248 Controller opens Channel A of the Morph-IC-II. Select the device port in accordance with the utility and click open as shown in Figure 10.

To carry out a quick communications test, type a few letters in the test tab and press return, if the EEPROM configuration, the wiring and loaded RBF are all correct for this application, the typed string will (if the setup is correct) transfer and be displayed on the text tab of the other utility. Illustrated in Figure 10, the strings "123" and "321" have been transferred from the UM232H to the Morph-IC-II and Morph-IC-II to the UM232H respectively using FT1248.



**Figure 10 – FT1248 Controller and Terminal.exe displaying a data transfer**

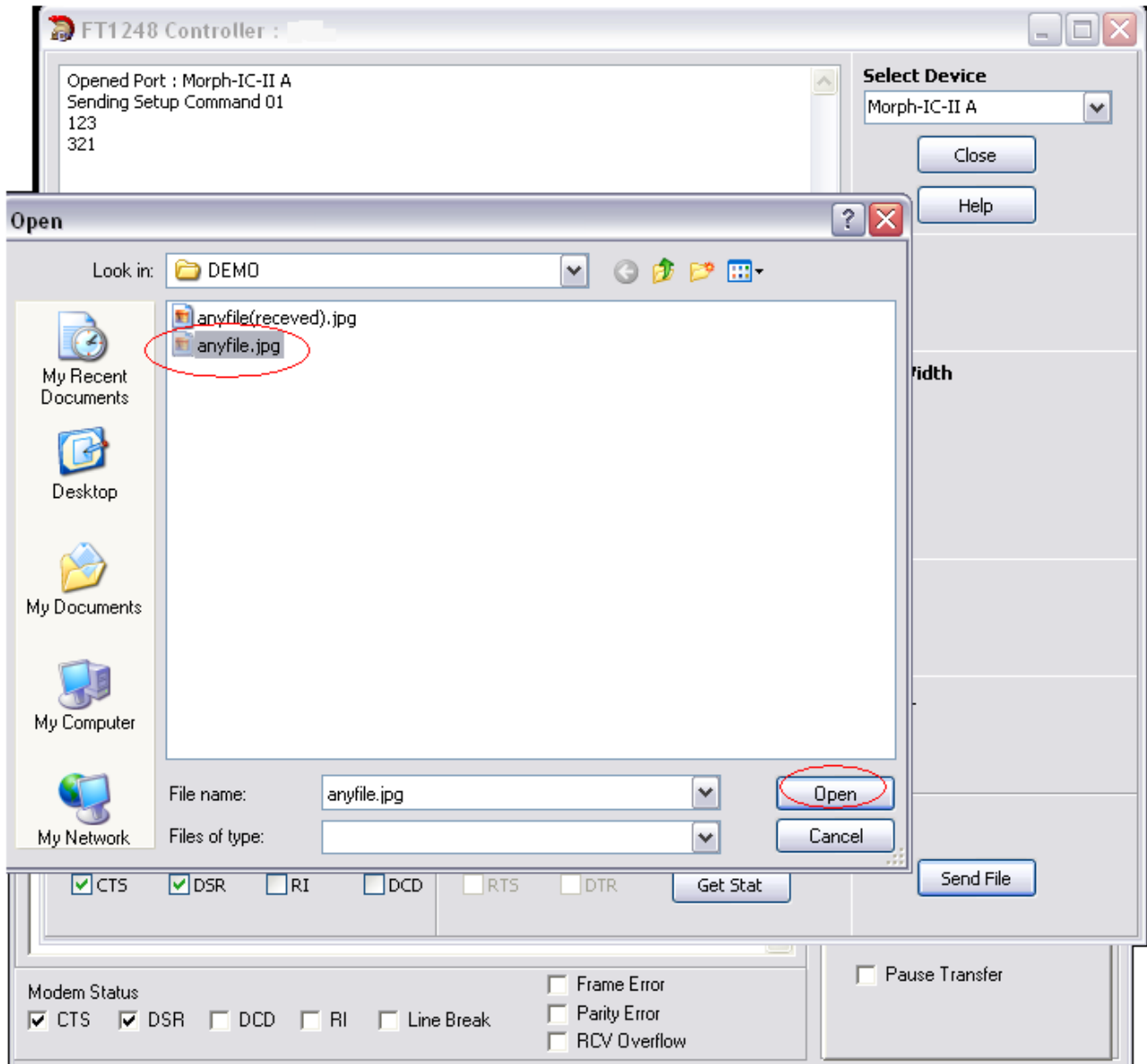
To further investigate the integrity of the established FT1248 interface, a file can be transfer from the Morph-IC-II to the UM232H. To do this use the terminal.exe application to designate a location for the transferred file, this is carried out by selecting the "file Xfer" tab, then selecting "RCV File", then define the name and the location of the file that will be created after the copy and transfer. These steps are illustrated in Figure 11.



**Figure 11 – Allocating a destination for a file being transferred**

To copy and transfer a file, in the FT1248 Controller window select "Send File", then navigate to the file you want to send, select the file and click open to transfer the file to the location defined in the previous operation. These steps are illustrated in Figure 11.

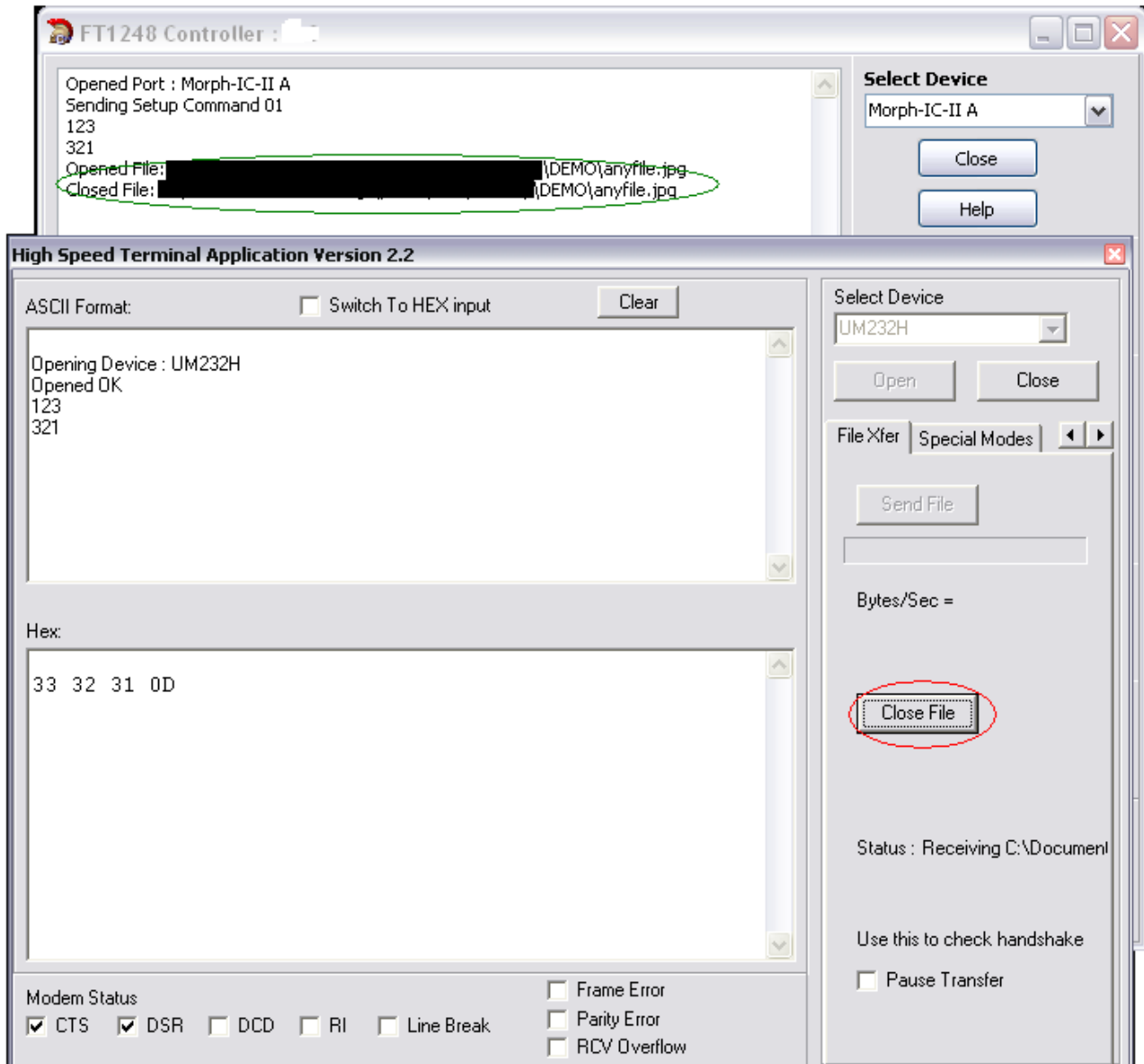




**Figure 12 – Transferring a file from the Morph-IC-II to the UM232H via FT1248**

Once the file has transferred the FT1248 Controller will automatically close the file, the transferred file needs to be manually closed at the terminal.exe side. This step is illustrated in Figure 13. To verify the file has been transferred correctly open the received file to see if it appears to be normal.

Transferring a file from the UM232H to the Morph-IC-II will test how data transfers in the opposite direction. This is carried out in a similar way, where the FT1248 Controller sets the location and name of the received file and the terminal program sends the file.



**Figure 13 – Transfer completed, close the port**

## 5 Summary

This application note provides a background of the interfaces and devices used in this FT1248 application, along with a procedure for establishing FT1248 communications.

## 6 Contact Information

### Head Office – Glasgow, UK

Future Technology Devices International Limited  
Unit 1, 2 Seaward Place, Centurion Business Park  
Glasgow G41 1HH  
United Kingdom  
Tel: +44 (0) 141 429 2777  
Fax: +44 (0) 141 429 2758

E-mail (Sales) [sales1@ftdichip.com](mailto:sales1@ftdichip.com)  
E-mail (Support) [support1@ftdichip.com](mailto:support1@ftdichip.com)  
E-mail (General Enquiries) [admin1@ftdichip.com](mailto:admin1@ftdichip.com)

### Branch Office – Hillsboro, Oregon, USA

Future Technology Devices International Limited (USA)  
7235 NW Evergreen Parkway, Suite 600  
Hillsboro, OR 97123-5803  
USA  
Tel: +1 (503) 547 0988  
Fax: +1 (503) 547 0987

E-Mail (Sales) [us.sales@ftdichip.com](mailto:us.sales@ftdichip.com)  
E-Mail (Support) [us.support@ftdichip.com](mailto:us.support@ftdichip.com)  
E-Mail (General Enquiries) [us.admin@ftdichip.com](mailto:us.admin@ftdichip.com)

### Branch Office – Taipei, Taiwan

Future Technology Devices International Limited (Taiwan)  
2F, No. 516, Sec. 1, NeiHu Road  
Taipei 114  
Taiwan, R.O.C.  
Tel: +886 (0) 2 8791 3570  
Fax: +886 (0) 2 8791 3576

E-mail (Sales) [asia.sales1@ftdichip.com](mailto:asia.sales1@ftdichip.com)  
E-mail (Support) [asia.support1@ftdichip.com](mailto:asia.support1@ftdichip.com)  
E-mail (General Enquiries) [asia.admin1@ftdichip.com](mailto:asia.admin1@ftdichip.com)

### Branch Office – Shanghai, China

Future Technology Devices International Limited (China)  
Room 1103, No. 666 West Huaihai Road,  
Shanghai, 200052  
China  
Tel: +86 21 62351596  
Fax: +86 21 62351595

E-mail (Sales) [cn.sales@ftdichip.com](mailto:cn.sales@ftdichip.com)  
E-mail (Support) [cn.support@ftdichip.com](mailto:cn.support@ftdichip.com)  
E-mail (General Enquiries) [cn.admin@ftdichip.com](mailto:cn.admin@ftdichip.com)

### Distributor and Sales Representatives

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## Appendix A – Abbreviations

Terms	Description
EEPROM	Electrically Erasable Programmable Read Only Memory
FIFO	First In First Out
FPGA	Field Programmable Gate Array
FTDI	Future Technology Devices International Ltd.
MPSSE	Multi-Protocol Synchronous Serial Engine
RBF	Raw Binary Format
UART	Universal Asynchronous Receiver Transmitter
USB	Universal Serial Bus

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## Appendix B – References

“MorphIC\_FT1248\_master” download

[http://www.ftdichip.com/Products/Files/MorphIC\\_FT1248\\_master.zip](http://www.ftdichip.com/Products/Files/MorphIC_FT1248_master.zip)

“Morph-IC-II Applications and Utilities” download

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UM232H Datasheet

[http://www.ftdichip.com/Support/Documents/DataSheets/Modules/DS\\_UM232H.pdf](http://www.ftdichip.com/Support/Documents/DataSheets/Modules/DS_UM232H.pdf)

Morph-IC-II

[http://www.ftdichip.com/Support/Documents/DataSheets/Modules/DS\\_Morph-IC-II.pdf](http://www.ftdichip.com/Support/Documents/DataSheets/Modules/DS_Morph-IC-II.pdf)

FT\_Prog

[http://www.ftdichip.com/Resources/Utilities/FT\\_PROG.zip](http://www.ftdichip.com/Resources/Utilities/FT_PROG.zip)

D2xx Programmers Guide

[http://www.ftdichip.com/Documents/ProgramGuides/D2XX\\_Programmer's\\_Guide\(FT\\_000071\).pdf](http://www.ftdichip.com/Documents/ProgramGuides/D2XX_Programmer's_Guide(FT_000071).pdf)

Interfacing FT2232H device to SPI

[http://www.ftdichip.com/Projects/MPSSE/AN\\_114\\_FTDI\\_Hi\\_Speed\\_USB\\_To\\_SPI\\_Example.pdf](http://www.ftdichip.com/Projects/MPSSE/AN_114_FTDI_Hi_Speed_USB_To_SPI_Example.pdf)

Recovery utility

[http://www.ftdichip.com/Resources/Utilities/SPI\\_Test.zip](http://www.ftdichip.com/Resources/Utilities/SPI_Test.zip)

Quartus-II

<http://www.altera.com/products/software/quartus-ii/web-edition/qts-we-index.html>

AN\_167 FT1248 Parallel Serial Interface Basics

[http://www.ftdichip.com/Support/Documents/AppNotes/AN\\_167\\_FT1248\\_Parallel\\_Serial\\_Interface\\_Basics.pdf](http://www.ftdichip.com/Support/Documents/AppNotes/AN_167_FT1248_Parallel_Serial_Interface_Basics.pdf)

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## Appendix C – Revision History

Revision	Changes	Date
1.0	First Issue	2011-09-12
1.1	Corrected Figure 4 – Morph-IC-II and FT232H wire scheme Updated contact information	2012-06-26