



**Future Technology Devices International Ltd.**

## **Application Note**

**An\_221**

# **Adding An ADC To The Raspberry Pi**

**Document Reference No.: FT\_000733**

**Version 1.0**

**Issue Date: 2012-08-02**

The Raspberry Pi is a single board computer based on an ARM processor aimed at teaching young people about computers and programming. FTDI have developed an expansion module for this Raspberry Pi, the RPI-Hub-Module. This application note explains how to use the RPI-Hub-Module as an SPI master to read an external ADC. Schematics and sample code will be provided.

---

## **Table of Contents**

<b>1</b>	<b>Introduction .....</b>	<b>2</b>
1.1	<b>Overview.....</b>	<b>2</b>
1.2	<b>Scope .....</b>	<b>2</b>
<b>2</b>	<b>Hardware .....</b>	<b>3</b>
2.1	<b>Block Diagram.....</b>	<b>3</b>
2.2	<b>ADC schematic .....</b>	<b>3</b>
2.3	<b>Hardware Function.....</b>	<b>4</b>
<b>3</b>	<b>Drivers .....</b>	<b>5</b>
<b>4</b>	<b>Application code.....</b>	<b>6</b>
4.1	<b>Source Code .....</b>	<b>6</b>
4.2	<b>Compiling Source Code .....</b>	<b>6</b>
4.3	<b>Running the example .....</b>	<b>6</b>
<b>5</b>	<b>Contact Information .....</b>	<b>9</b>
<b>6</b>	<b>Appendix A – References.....</b>	<b>10</b>
	<b>Document References .....</b>	<b>10</b>
	<b>Acronyms and Abbreviations .....</b>	<b>10</b>
<b>7</b>	<b>Appendix B – List of Tables &amp; Figures .....</b>	<b>11</b>
<b>8</b>	<b>Appendix C – Revision History.....</b>	<b>12</b>

## 1 Introduction

The Raspberry Pi is a single board computer (SBC) based on an ARM processor aimed at teaching young people about computers and programming. FTDI have developed an expansion module for this Raspberry Pi based on the FT2232H, the RPI-Hub-Module. This application note explains how to use the RPI-Hub-Module as an SPI master to read an external ADC. Schematics and sample code will be provided.

### 1.1 Overview

The Raspberry Pi is a single board computer primarily running Linux OS. The board has a number of IO ports for developing applications with, including 2 USB host ports. With the RPI-Hub-Module connected to the Raspberry Pi USB port, FTDI can demonstrate using an FTDI chipset operating on an ARM processor running Linux to expand the IO options of the Raspberry Pi while also offering buffered protection to the processor from badly connected external peripherals.



The RPI-Hub-Module is a FT2232H based design allowing for 2 independent interfaces which may be configured for GPIO, UART, FIFO, I2C or SPI etc. The module also includes a USB hub creating an additional 2 USB host ports. More information on the hub can be found [here](#).

**Figure 1.1 RPI-Hub-Module**

More information on the Raspberry Pi can be found [here](#).

### 1.2 Scope

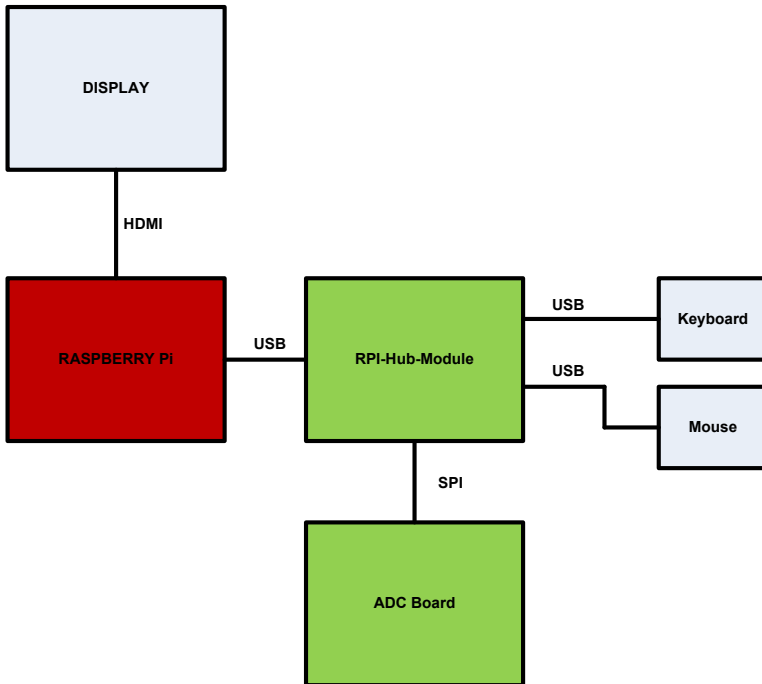
This application note assumes the user has already created a working Linux image on an SD card and the Raspberry Pi is already functional.

This application note will show how to connect the RPI-Hub-Module to the Raspberry Pi and install FTDI drivers to control the module. The application note will then explain how the module may be used to read values from an external ADC device over the SPI interface.

## 2 Hardware

### 2.1 Block Diagram

The setup for this reference design is as shown in the following block diagram.



**Figure 2.1 Block Diagram**

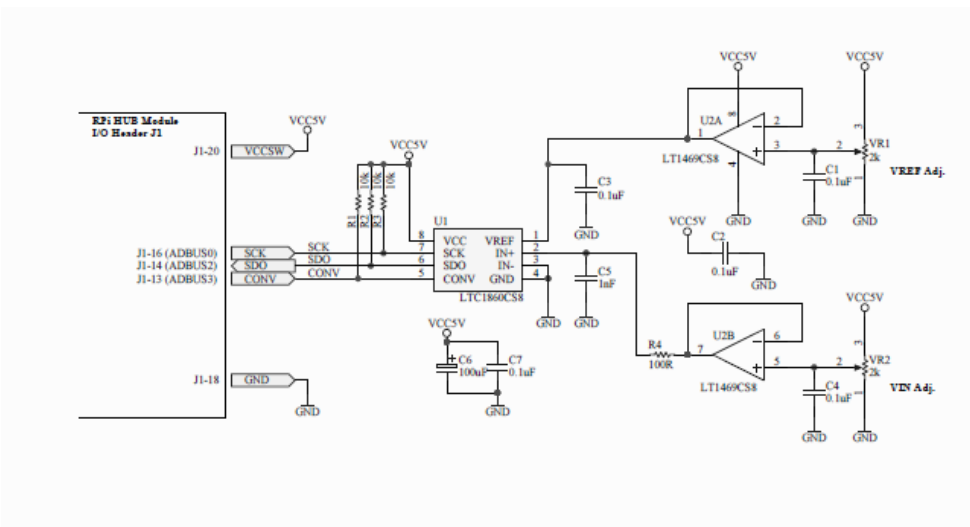
The red block is the Raspberry Pi small board computer where the code is running.

The blue blocks are standard PC peripherals, although note the display requires an HDMI input.

The green blocks are developed by FTDI.

### 2.2 ADC schematic

The schematic for the ADC board in the setup is shown here.



**Figure 2.2 ADC Board schematic**

## 2.3 Hardware Function

The hardware operates by providing a supply input to a Linear Technologies LTC1860 – 12 bit, 250ksamples/s ADC.

Variable resistor VR1 provides a reference input and variable resistor VR2 provides the changing input. The LTC1860 converts this input to a digital value transferred over SPI to the FT2232H on the RPI-Hub-Module which can be read by the Raspberry Pi processor to allow for values to be shown on the display.

### 3 Drivers

When the hardware is all connected, the RPI-Hub-Module requires FTDI drivers to be loaded to access the FT2232H functions. This application is using the Multi-Purpose-Synchronous-Serial-Engine (MPSSE) of the FT2232H and as such requires the D2xx driver to be loaded. As this is a "user mode" driver as opposed to a "kernel mode" driver the installation is simply a case of copying the file to the Raspberry Pi SD card and making a symbolic link as described below.

Using the internet browser on the Raspberry Pi, download the driver file onto the SD card from

<http://www.ftdichip.com/Drivers/D2XX/Linux/libftd2xx1.1.12.tar.gz>

(note this is driver version 1.1.12 – check for later versions when performing this step).

Open a terminal window. This is one of the applications provided with the basic Raspberry Pi kernel.

In the terminal window use the "cd" command to move to the folder where the downloaded file was saved to.

Now type the following commands:

1. `tar xfvz libftd2xx1.1.12.tar.gz`

This unpacks the archive, creating the following directory structure:

```
build
  arm926
  i386
  x86_64
examples
libusb
ftd2xx.h
WinTypes.h
```

2. `cd build/arm926`

3. `sudo -s`  
or, if sudo is not available on your system:  
`su`

Promotes you to super-user, with installation privileges. If you're already root, then step 3 (and step 7) is not necessary.

4. `cp lib* /usr/local/lib`

Copies the libraries to a central location.

5. `chmod 0755 /usr/local/lib/libftd2xx.so.1.1.12`

Allows non-root access to the shared object.

6. `ln -sf /usr/local/lib/libftd2xx.so.1.1.12 /usr/local/lib/libftd2xx.so`

Creates a symbolic link to the 1.1.12 version of the shared object.

7. `exit`

These instructions can be found online at:

<http://www.ftdichip.com/Drivers/D2XX/Linux/ReadMe-linux.txt>

## 4 Application code

### 4.1 Source Code

The application code was developed in C and is available as source code from the link [here](#).

The application uses the basic D2xx function calls:

- FT\_ListDevices – to detect the device connected
- FT\_Open – to open a handle to the device interface for further commands to be sent to.
- FT\_Purge – cleans out the buffers to prevent erroneous data at the start.
- FT\_SetBitMode – to access MPSSE mode
- FT\_Read – To read the ADC data
- FT\_Write – To send commands to the FT2232H MPSSE
- FT\_Close – To close the handle

How to use these function calls are all defined in the [D2xx Programmers Guide](#).

The instruction set for MPSSE is defined in [AN\\_108 Command Processor for MPSSE and MCU Host Bus Emulation Modes.pdf](#)

### 4.2 Compiling Source Code

On a linux machine the executable file is termed an object file with the extension .o.

To create the object file from the source code (extension.c) the user must use the terminal window to browse to the folder containing the file and then use the following command:

```
gcc main.c -o adc -Wall -Wextra -L. -lftd2xx -ldl -lpthread -lrt -Wl,-rpath /usr/local/lib
```

(note gcc is the compiler tool and should be part of the basic kernel)

The output of this will be a file named adc.o in the same folder as main.c.

### 4.3 Running the example

To run the example the FTDI Virtual Com Port (VCP) driver must be unloaded. This loads by default when an FTDI device is plugged in as it is part of the kernel.

In the terminal window send the following commands.

```
sudo rmmod ftdi_sio  
sudo rmmod usbserial
```

Now run the application with the command

```
sudo ./adc
```

The value from the ADC will now be printed on the display. The user can adjust the variable resistor and repeat the reading. This should change the value printed on the display.

## 5 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

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

Please visit the Sales Network page of the [FTDI Web site](#) for the contact details of our distributor(s) and sales representative(s) in your country.

System and equipment manufacturers and designers are responsible to ensure that their systems, and any Future Technology Devices International Ltd (FTDI) devices incorporated in their systems, meet all applicable safety, regulatory and system-level performance requirements. All application-related information in this document (including application descriptions, suggested FTDI devices and other materials) is provided for reference only. While FTDI has taken care to assure it is accurate, this information is subject to customer confirmation, and FTDI disclaims all liability for system designs and for any applications assistance provided by FTDI. Use of FTDI devices in life support and/or safety applications is entirely at the user's risk, and the user agrees to defend, indemnify and hold harmless FTDI from any and all damages, claims, suits or expense resulting from such use. This document is subject to change without notice. No freedom to use patents or other intellectual property rights is implied by the publication of this document. Neither the whole nor any part of the information contained in, or the product described in this document, may be adapted or reproduced in any material or electronic form without the prior written consent of the copyright holder. Future Technology Devices International Ltd, Unit 1, 2 Seaward Place, Centurion Business Park, Glasgow G41 1HH, United Kingdom. Scotland Registered Company Number: SC136640



## 6 Appendix A – References

### Document References

RPI-Hub-Module Datasheet

[http://www.ftdichip.com/Support/Documents/DataSheets/Modules/DS\\_RPi\\_HUB\\_Module.pdf](http://www.ftdichip.com/Support/Documents/DataSheets/Modules/DS_RPi_HUB_Module.pdf)

Raspberry Pi Home Page

<http://www.raspberrypi.org/>

LTC1860 datasheet

<http://cds.linear.com/docs/Datasheet/18601fa.pdf>

D2xx driver installation instructions

<http://www.ftdichip.com/Drivers/D2XX/Linux/ReadMe-linux.txt>

D2xx Programmers Guide

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

AN\_108\_Command\_Processor\_for\_MPSSE\_and\_MCU\_Host\_Bus\_Emulation\_Modes

[http://www.ftdichip.com/Support/Documents/AppNotes/AN\\_108\\_Command\\_Processor\\_for\\_MPSSE\\_and\\_MCU\\_Host\\_Bus\\_Emulation\\_Modes.pdf](http://www.ftdichip.com/Support/Documents/AppNotes/AN_108_Command_Processor_for_MPSSE_and_MCU_Host_Bus_Emulation_Modes.pdf)

Source code

[http://www.ftdichip.com/Support/FTReferenceDesigns.html/ADC\\_source.zip](http://www.ftdichip.com/Support/FTReferenceDesigns.html/ADC_source.zip)

ADC board schematic

[http://www.ftdichip.com/Support/FTReferenceDesigns.html/RPI\\_ADC\\_schematic.zip](http://www.ftdichip.com/Support/FTReferenceDesigns.html/RPI_ADC_schematic.zip)

### Acronyms and Abbreviations

Terms	Description
ADC	Analogue to Digital Converter
DLL	Dynamic Link Library
SBC	Single Board Computer
USB	Universal Serial Bus
VCP	Virtual Com Port

## **7 Appendix B – List of Tables & Figures**

### **List of Tables**

No table of figures entries found.

### **List of Figures**

<b>Figure 1.1 RPI-Hub-Module .....</b>	<b>2</b>
<b>Figure 2.1 Block Diagram .....</b>	<b>3</b>
<b>Figure 2.1 ADC Board schematic.....</b>	<b>3</b>

## 8 Appendix C – Revision History

Document Title: AN\_221 Adding an ADC to the Raspberry Pi  
Document Reference No.: FT\_000733  
Clearance No.: FTDI# 311  
Product Page: <http://www.ftdichip.com/FTProducts.htm>  
Document Feedback: [Send Feedback](#)

Revision	Changes	Date
1.0	Initial Release	2012-08-02