



Future Technology Devices International Ltd.

Application Note AN_102

Data-Logging Using the Vinculum VNC1L

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This application note describes methods for interfacing a data-logging application to a VNC1L. The examples demonstrate using the UART Interface, Command Monitor, USB device commands and disk access commands of the VNC1L.

The techniques used in this application note are applicable to the whole range of VNC1L-based modules and applications.

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1 Preface

The objective of this document is to demonstrate the use of a VNC1L device in data logging projects.

Any software code examples given in this document are for information only. The examples are not guaranteed and are not supported by FTDI.

1.1 Conventions

The following conventions are used in this document:

Convention	Description
Monospaced type	Indicates input or output from the monitor.
Boldface monospaced type	Indicates input supplied by the user.
<i>Italic monospaced type</i>	Indicates binary characters.
Important	Signals that the information supplied is important.
Note	Provide additional information about a topic.
Warning	Indicate potential damage to equipment or loss of data.
:	Is used to show a range. For instance, a range of bits 15:9 is bits 15 to 9 (inclusive) of a binary value.
VNC1L	Indicated information specific to the VNC1L device.
↵	carriage return (0x0D).
·	space (0x20).
<i>d</i>	Represents a single decimal character (0 to 9).
<i>x</i>	Represents a single hexadecimal character (0 to 9 and A to F).
<i>c</i>	Represents a binary character (0x00 to 0xFF).

Table 1.1 Document Conventions

1.2 Acronyms and Abbreviations

The following terms are used within this document:

Terms	Description
8.3	A filename format consisting of 1 to 8 characters, optionally followed by a period ('.') then an extension of up to 3 characters. For example, "TEST.TXT", "ANEWFILE.1" or "AFILE".
FAT	File Allocation Table. The name for the file system typically used for USB Flash Disks. Variants are FAT12, FAT16 and FAT32, the numbers referring to the number of bits used to specify a cluster on the disk.
BOMS	Bulk Only Mass Storage. A general description given to a USB mass storage device e.g. USB Flash Disk.
Monitor	Command line interface which allows instructions to be given to the VNC1L and responses to be returned.
Sector Size	The size of data which is read from or written to a disk in a single operation.

Table 1.2 Acronyms and Abbreviations

2 Introduction

The VNC1L IC and firmware libraries provided by FTDI allow embedded systems to communicate easily with USB devices. Using the VNC1L device, microcontrollers can now be interfaced with a range of USB devices including Bulk Only Mass Storage Class (BOMS), Communication Device Class (CDC), Printer Class, Human Interface Device (HID) class devices and USB hubs.

This application note provides a practical demonstration of the capabilities of the VNC1L. It shows how to program a PIC microcontroller to issue commands to the firmware command monitor of the VNC1L in order to control a VEval board.

The ESUART interface on a PIC microcontroller is connected to the UART interface on the VNC1L. Code modules are used to send and receive commands and data to the VNC1L as well as managing and decoding the responses from the VNC1L.

Two applications are described: the first application is a simple data logger which reads values from a USB tilt sensor module and records the data on a USB Flash disk, the second application is described for sampling an analogue input to the PIC microcontroller and storing the data on a USB Flash disk.

Implementation details for communicating with the VNC1L using the UART interface are provided. Disk and USB device access commands are also described in detail. Other features of the projects that are not specifically related to the function of the VNC1L device and are left to the user to interpret.

3 Requirements

3.1 Hardware

This application note requires a VEval board, a Microchip PICDEM 4 Demo Board and a connecting cable. Two demonstration projects are described. The first, VLogger, requires a DLP-TILT USB module as a data source. The second, VAcq, uses an ST Microelectronics accelerometer development module as an analogue input source.

On the PICDEM 4 board a PIC18F1320 microcontroller is needed to run the provided code.

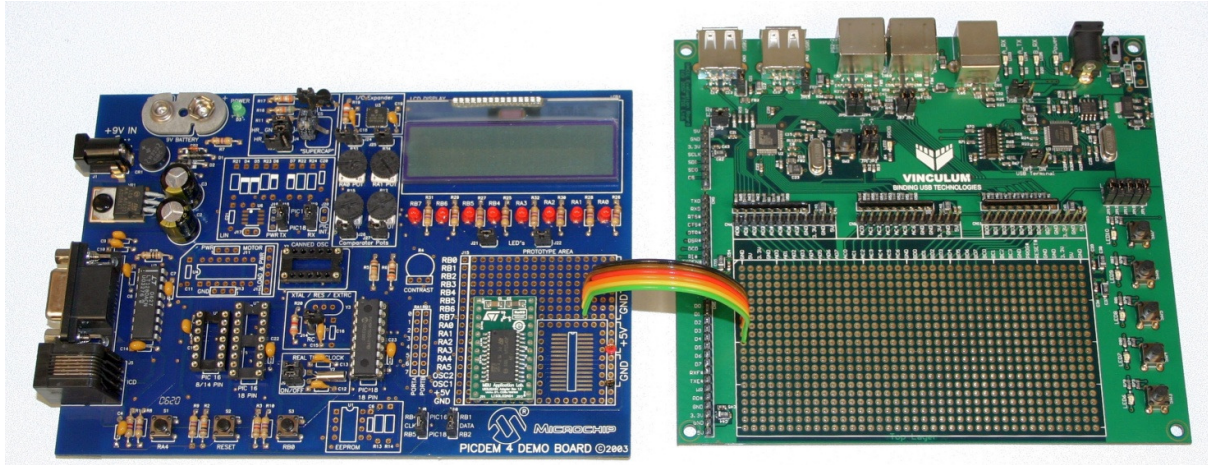


Figure 3.1 VLogger Application Demo Hardware

The connecting cable comprises four I/O signals, +5V and GND signals. The I/O signals carry the UART interface signals – Tx, Rx, CTS and RTS. Table 3.1 shows the connections required on the VEval board. Table 3.2 lists the connections for the cable on the PICDEM 4 board.

Pin Number	Signal Name	Colour
AD3	CTS#	Green
AD0	Tx	Orange
AD1	Rx	Yellow
+5V	+5V	Red
AD2	RTS#	Brown
GND	GND	Black

Table 3.1 VEval Connections

Pin Number	Signal Name	Colour
RB3	RTS#	Green
RB1	Rx	Yellow
RB4	Tx	Orange
+5V	+5V	Red
RB2	CTS#	Brown
GND	GND	Black

Table 3.2 PICDEM 4 Connections

The VEval board must have jumpers JP1 and JP2 set to UART mode – refer to the VEval board User Manual.

J10 on the PICDEM 4 board must be set to select PIC18 operation mode. By default the project code is set to use the internal oscillator on the PIC microcontroller. J24 must also be removed to disconnect the RA0 potentiometer and allow the accelerometer output to be connected to the RA0 input. The Vx output of the accelerometer was connected to the RA0 input of the PIC using the prototype area of the PICDEM 4 module.

A USB Flash disk is connected to USB Port 2 on the VEval board.

In this configuration, only the PICDEM 4 board should be powered. The VEval board will be powered by 5V supplied from the PICDEM 4 board. The VEval board will convert the supply to 3.3V for use by the VNC1L and the ST Microelectronics accelerometer.

3.2 Firmware

The VNC1L device on the VEval board must be programmed with VDAP firmware version V3.64 or later for these projects. The VNC1L firmware commands are fully documented in the VNC1L Firmware User Manual.

3.3 Software

Sample C code for the PIC18F1320 microcontroller is available as a free download from the FTDI web site. The code for the PIC microcontroller must be compiled with SourceBoost C or ported to an equivalent compiler before being programmed onto the device.

Two sample applications are provided in this application note. Common code is used to manage the UART interface and the command monitor.

USB Flash disks are also used by both applications although the methods used for writing data to files is different.

3.3.1 VLogger

The VLogger sample application demonstrates a method of requesting and receiving data from a USB sensor device connected to USB Port 1 on the VEval board. Data is stored on a USB Flash disk on USB Port 2.

The USB device used is a DLP-TILT module which consists of an accelerometer and PIC microcontroller interfaced to USB using an FT232 device.

The connector described in Table 3.1 and Table 3.2 is represented by the grey double headed arrow in Figure 2.

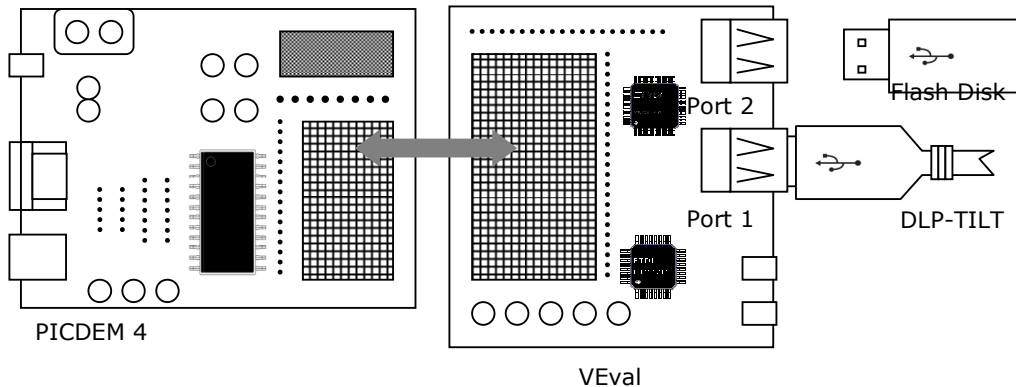


Figure 2 VLogger Connection Diagram

This application shows how to setup communications with a USB device and how to send data to and receive data from a device.

3.3.2 VAcq

In the VAcq program, an analogue sensor is connected directly to an Analogue to Digital Converter input of the PIC microcontroller. Timed samples of the sensor output are stored on a USB Flash disk on USB Port 2 of the VEval board.

The analogue data source used in this case is an STEVAL-MKI010V1 MEMS accelerometer from ST Microelectronics. This supplies analogue voltage outputs for X, Y and Z-axis. Only the output from one axis is connected to the PIC microcontroller.

The connector described in Table 3.1 and Table 3.2 is represented by the grey double headed arrow in Figure 3. The connection between the accelerometer and the PICDEM 4 board is shown by the white arrow.

The accelerometer must be powered by a 3.3V supply. The VEval board derives 3.3V from the 5V drawn from the PICDEM4 board. This can be used, with additional wiring, for the accelerometer or a dedicated voltage regulator can be placed on the PICDEM 4 board to supply 3.3V.

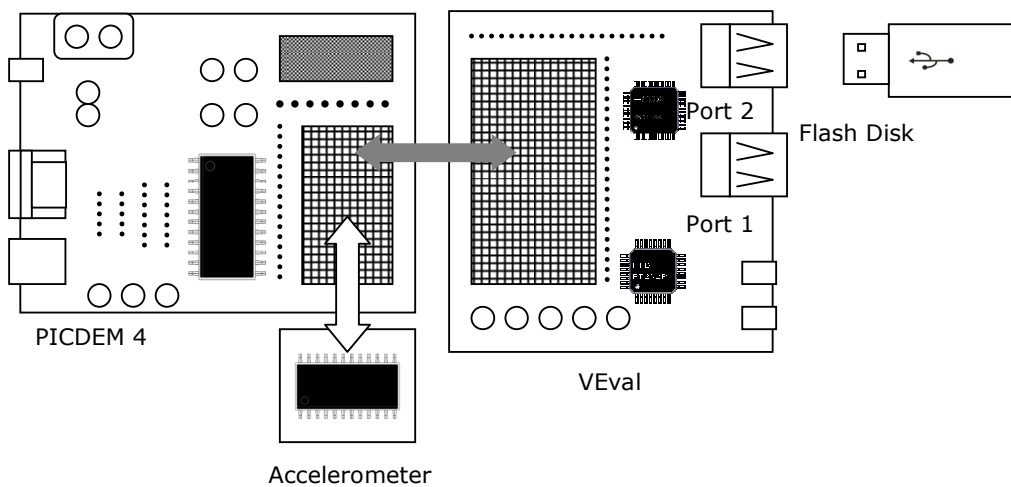


Figure 3 VAcq Connection Diagram

The application shows how to batch data to stream to a USB Flash disk for maximum performance.

4 UART Interface Module

The UART interface module controls the application's physical communication with the UART interface on the VNC1L. The files UART.c and UART.h manage the EUSART interface of the PIC microcontroller and perform RTS/CTS flow control.

The code creates a software FIFO buffer for data received by the PIC microcontroller from the VNC1L. An interrupt is generated by the PIC microcontroller each time a character is received and this data is added to the FIFO buffer. The application can query the FIFO buffer to determine if data has been received. Data is transmitted by the PIC microcontroller sequentially without the use of buffering.

Flow control is handled by the UART interface module to ensure data is sent only when the receiving device is ready.

Each callable function in the UART interface module is aliased using a pre-processor definition to allow the entire module to be replaced by a functionally equivalent module for handling communications. In the case of the VNC1L this may be an SPI or Parallel FIFO interface. The calling application should only use the generic interface routine names and not the UART-specific ones. The definitions included in the UART.h file and are shown in Figure 3.

```
#define monInit    uartInit
#define monRead   uartRead
#define monReadWait  uartReadWait
#define monWrite  uartWrite
#define monInterrupt  pirl.RCIF
#define monInterruptHandler  uartRx
```

Figure 4.1 Monitor Callable Functions for UART Interface

4.1 Pin Definitions

The UART interface between the PICDEM 4 and the VNC1L on the VEval board utilises 4 signals. The pin definitions for the signals used by the UART interface on the PIC microcontroller are shown in Figure 4.

```
#define PORT_RX    portb.1           // RX is RB1 (Port B bit 1)
#define TRIS_RX    trisb.1

#define PORT_RTS   portb.3           // RTS# is RB3 (Port B bit 3)
#define TRIS_RTS   trisb.3

#define PORT_TX    portb.4           // TX is RB4 (Port B bit 4)
#define TRIS_TX    trisb.4

#define PORT_CTS   portb.2           // CTS# is RB2 (Port B bit 2)
#define TRIS_CTS   trisb.2
```

Figure 4.2 UART Pin Definition Code

The UART interface pins on the VNC1L are listed in the VNC1L Datasheet and VNC1L Firmware User Manual. Tx on the PIC microcontroller must be connected to Rx on the VNC1L, Rx on the PIC to Tx on the VNC1L, similarly CTS# and RTS# must also be crossed.

4.2 External Functions

The UART interface code presents 4 subroutines externally:

- `uartInit` – initialise the EUSART registers and interface I/O pins on the PIC microcontroller.
- `uartRead` – check UART interface for available byte of data.
- `uartReadWait` – wait until a byte is received on the UART interface.
- `uartWrite` – write a byte of data to the UART interface.

These subroutines are called by the command monitor module (see Section 5) to allow an application to interact with the VNC1L firmware.

4.2.1 uartInit

Initialise the PIC microcontroller EUSART interface and the UART FIFO buffer.

Definition

```
void uartInit()
```

Parameters

None

Return Value

None

Calls

None

Remarks

This routine sets up the PIC microcontroller EUSART interface and flow control pins. RTS# is configured as an output and CTS# as an input. The RTS# output is set low to signal the PIC microcontroller is able to accept data.

The EUSART is initialised to 9600 baud, 1 stop bit, no parity. These UART settings are the default settings on the VNC1L firmware. The Vinculum Firmware Customiser Application (available from the FTDI website) can be used to modify these values.

Interrupts are enabled to allow data from the VNC1L command monitor to be added to the UART FIFO buffer.

4.2.2 uartRead

Return a byte of data from the UART FIFO buffer.

Definition

```
char uartRead(char *pUartData)
```

Parameters

**pUartData* – pointer to variable to receive data read from UART FIFO buffer.

Return Value

Zero if data read successful, 1 if unsuccessful.

Calls

None

Remarks

If data is available in the UART FIFO buffer this routine will move the first byte of data from the buffer to the byte pointed to by parameter *pUartData* and return zero. If no data is present in the UART FIFO buffer then the routine will return 1.

If the number of data bytes stored in the UART FIFO buffer falls below a lower threshold value then the routine will set the RTS# pin low (active) allowing more data to be sent to the PIC microcontroller by the VNC1L.

4.2.3 uartReadWait

Wait until a byte of data is available from the UART FIFO buffer.

Definition

```
char uartReadWait()
```

Parameters

None

Return Value

Data read from UART FIFO buffer.

Calls

uartRead

Remarks

Repeatedly calls `uartRead` until a byte of data is available in the UART FIFO buffer. The byte of data received from `uartRead` is returned.

4.2.4 uartWrite

Write a single byte of data to the EUSART on the PIC microcontroller.

Definition

```
void uartWrite(char uartData)
```

Parameters

uartData – data to write to the UART interface.

Return Value

None

Calls

None

Remarks

This routine waits until any previous data transmission has been completed before transmitting the byte to the EUSART. Then it checks that the CTS# input is active (low) before proceeding with the transmission. This ensures that the VNC1L is ready to accept data from the PIC microcontroller.

4.3 Interrupt Functions

The `monInterrupt` definition is used in the application's interrupt handler routine to route interrupts to the `monInterruptHandler` routine for servicing.

4.3.1 uartRx

Interrupt handler routine for receiving data from the EUSART on the PIC microcontroller.

Definition

```
void uartRx()
```

Parameters

None

Return Value

None



Calls

None

Remarks

When a EUSART interrupt is signalled the application interrupt handler must call this routine to service the interrupt. The interrupt status bit in the PIC microcontroller interrupt request register is reset.

The interrupt handler reads a byte of data received from the EUSART controller on the PIC microcontroller and adds it to the UART FIFO buffer.

The RTS# output is set high (inactive) if the number of data bytes stored in the UART FIFO buffer reaches an upper threshold.

5 Command Monitor Module

The command monitor module calls subroutines in the UART interface module to communicate with the VNC1L firmware. Source code provided in the monitor.c and monitor.h files controls the sending of commands to the VNC1L, and receiving and interpreting the responses.

There are several responses which can come from each command sent to the VNC1L firmware. Figure 5 lists the enumeration of these responses from the VNC1L firmware from the monitor.h file.

```
// Prompts and messages returned by VNC1L in Short Command Set

enum vResponse {
    // Prompts returned by all VNC1L firmware
    Resp_Prompt_OK, // > (Success)
    Resp_Prompt_ND, // ND (Success)
    Resp_Prompt_UE, // E echo
    Resp_Prompt_LE, // e echo
    Resp_Prompt_CF, // CF (Command Failed)
    Resp_Prompt_BC, // BC (Bad Command)
    Resp_Prompt_DF, // DF (Disk Full)
    Resp_Prompt_FI, // FI (File Invalid)
    Resp_Prompt_RO, // RO (Read Only)
    Resp_Prompt_FO, // FO (File Open)
    Resp_Prompt_NE, // NE (Dir Not Empty)
    Resp_Prompt_FN, // FN (Filename Invalid)
    Resp_Prompt_End,
    // Asynchronous messages returned by all VNC1L firmware
    Resp_Message_NU, // NU / No Upgrade
    Resp_Message_DD1, // DD1 / Device Detected USB Port 1)
    Resp_Message_DD2, // DD2 / Device Detected USB Port 2)
    Resp_Message_DR1, // DR1 / Device Removed USB Port 1)
    Resp_Message_DR2, // DR2 / Device Removed USB Port 2)
    Resp_Message_Splash, // Ver ...
    Resp_None = 0xff,
};
```

Figure 5.1 Monitor Response Enumeration

5.1 External Functions

5.1.1 monSendByte

Send a single byte of data to the VNC1L.

Definition

```
void monSendByte(char monData)
```

Parameters

monData – byte of data to write to interface.

Return Value

None

Calls

monWrite

Remarks

This command transfers a byte of data to the UART interface module. It has an inline specifier due to the simplicity of the function.

5.1.2 monCmdSend

Send a command with no parameters to the VNC1L.

Definition

```
void monCmdSend(char monCmd)
```

Parameters

monCmd – command byte to write to interface.

Return Value

None

Calls

monWrite

Remarks

This command writes the command byte passed as a parameter to the UART interface module. It follows the command byte with a carriage return character if required.

5.1.3 monCmdSendByteParam

Send a command with a single byte parameter to the VNC1L.

Definition

```
void monCmdSendByteParam(char monCmd, unsigned char monParam)
```

Parameters

monCmd – command byte to write to interface.

monParam – single byte to be sent as parameter.

Return Value

None

Calls

monWrite

Remarks

This command writes the command byte passed as a parameter to the UART interface module. Then it sends a space character to delimit the parameter. The single-byte parameter *monParam* is sent followed by a carriage return.

5.1.4 monCmdSendParam

Send a command with a variable parameter length to the VNC1L.

Definition

```
void monCmdSendParam(char monCmd, unsigned char monCount, unsigned char *pmonParam)
```

Parameters

monCmd – command byte to write to interface.

monCount – count of bytes to send as parameters to interface.

**pmonParam* – pointer to array of bytes to be sent as parameters.

Return Value

None

Calls

monWrite

Remarks

This command writes the command byte passed as a parameter to the UART interface module. Then it sends a space character to delimit the parameters. The parameters consist of *monCount* bytes; the data is passed in the *pmonParam* array. The command and parameters are followed by a carriage return.

5.1.5 monResponse

Wait until a valid prompt, error message or status message is returned by the VNC1L.

Definition

```
enum vResponse monResponse()
```

Parameters

None

Return Value

Enumeration of prompt or error response command returns.

Calls

monRead

Remarks

After a command has been sent to the VNC1L, it will always return a response indicating success or an error condition. The *monResponse* subroutine compares the data returned from the command monitor to a list of expected responses and returns a matching value from an enumeration list. This can be used by the calling application to check for the expected behaviour of the device.

5.1.6 monPrompt

Wait until a valid prompt or error message is returned by the VNC1L.

Definition

```
enum vResponse monPrompt()
```

Parameters

None

Return Value

Enumeration of prompt or error response command returns.

Calls

monResponse

Remarks

In the enumeration *vResponse*, *Resp_Prompt_End* marks the last valid prompt or error message in the list. Subsequent values indicate asynchronous messages which may be sent by the VNC1L.

5.2 Internal Functions

There are no internal functions in the command monitor module.



5.3 Interrupts

To allow the command monitor to receive data from the UART Interface Module it requires the code in Figure 5.2 to be included in the `interrupt()` handler of the application.

```
// handle interrupts (if any) from monitor
if (monInterrupt)
{
    monInterruptHandler();
}
```

Figure 5.2 Interrupt Handling

6 Common Application Code

The code in this section is used by the VLogger and VAcq applications.

6.1 Initialisation

The first task of the application is to establish a connection to and synchronise with the VNC1L firmware monitor. This is best accomplished by sending and receiving echo commands until the state of the VNC1L is known. The code in Figure 6.1 repeatedly sends out a capital 'E' character followed by a lower-case 'e' character until the VNC1L echoes the characters back in the same order.

```
// ensure VNC1L is synchronised and placed into SCS mode
// ignore all messages and prompts until sync operation completes
while (1)
{
    clear_wdt();
    // clear all outstanding messages pending in FIFO
    do
    {
        resp = monResponse();
    } while (resp != Resp_None);

    monCmdSend('E');
    while (monPrompt() != Resp_Prompt_UE);

    monCmdSend('e');
    if (monPrompt() == Resp_Prompt_LE)
    {
        // change to Short Command Set Mode
        monCmdSend(CMD_SCS);
        resp = monPrompt();
        if (resp == Resp_Prompt_OK)
        {
            break;
        }
    }
}
```

Figure 6.1 Synchronisation with Echo Commands

Next, the application changes the VNC1L firmware monitor to use the Short Command Set. This reduces the length of commands and responses making sending commands and parsing responses easier.

It is possible to modify the VNC1L firmware using the Vinculum Firmware Customiser Application to change the start-up mode of the VNC1L from Extended Command Set to Short Command Set. This would allow this step to be skipped.

6.2 Storage Directory Creation

Before commencing operation both applications create a directory on the Flash disk where output files can be placed. Source code is shown in Figure 6.2. This utilises the MKD (Make Directory) command to create a sub-directory. The response of the MKD command is not checked since the directory may already exist from a previous time the application was run.

```
// create logging directory
for (i = 0; i < 4; i++)
{
    filename[i] = dirName[i];
}
monCmdSendParam(CMD_MKD, 4, filename);
resp = monPrompt();
// change directory to logging directory
monCmdSendParam(CMD_CD, 4, filename);
resp = monPrompt();
if (resp != Resp_Prompt_OK)
{
    // make directory or cd failed
    error = errDirectory;
    break;
}
```

Figure 6.2 Directory Creation

The applications perform a CD (Change Directory) command into the directory. If the directory does not exist or it is unable to perform the command then it will report an error.

6.3 Unique Filename Creation

The next operation is to parse the output of the DIR (Directory List) command to create a unique filename - Figure 6.3. A template filename is generated and the numeric value incremented until no files with that exact name are detected.

```
// create template for unique filename
for (i = 0; i < 12; i++)
{
    filename[i] = fileFormat[i];
}
// loop through possible filenames until a unique combination found
while (1)
{
    // perform a dir to see if filename exists
    monCmdSendParam(CMD_DIR, 11, filename);
    // carriage return precedes file information returned by dir command
    monReadWait();
    // an OK prompt indicates file already exists
    resp = monPrompt();
    if (resp != Resp_Prompt_OK)
    {
        // filename does not exist on disk (filename is unique)
        break; // from while
    }
    // increment counter in filename
    for (i = 7; i > 3; i--)
    {
        if (++filename[i] > '9')
        {
            filename[i] = '0';
        }
        else
        {
            break; // from for loop
        }
    }
}
}
```

Figure 6.3 Unique Filename Creation



6.4 Completing Sampling

Once sampling has been completed and the data file has been closed, the applications change the current directory back to the root directory from the storage directory. The filename is changed to “.” and the CD (Change Directory) command used to move to the parent directory.

```
// change back up a directory
filename[0] = filename[1] = '.';
monCmdSendParam(CMD_CD, 2, filename);
resp = monPrompt();
if (resp != Resp_Prompt_OK)
{
    // cd .. failed
    error = errDirectory;
    break;
}
```

Figure 6.4 Return to Parent Directory

7 VLogger Application

The application identifies the DLP-TILT module and verifies that a Flash disk is available on which to store data. Then it waits for a button on the PICDEM 4 module to be pressed before creating a unique filename in a subdirectory on the Flash disk.

After this it will periodically request data from the DLP-TILT module and write that data to the file on the Flash disk. A timer in the PIC microcontroller is used to generate samples at the rate of approximately 1 per second. Data is stored in Comma Separated Values (CSV) file format suitable for importing into a spreadsheet application for analysis.

Data read from the DLP-TILT is formatted and stored in a buffer before being written to disk. This buffer is referred to as the data FIFO and is accessed using `bufPush()` and `bufPop()` function calls. The number of bytes stored in the buffer is available in the global variable `bufCount`.

This application note does not explain the use of PIC microcontroller timers used in the VLogger application.

When the application is ready to commence sampling the LED RB5 will blink briefly approximately once every 2 seconds. If a Flash disk or DLP-TILT module is not detected the LED RB5 will flash rapidly. Button S1 (RA4) is used to start and stop sampling. The LED RB5 will flash slowly when sampling is taking place.

7.1 USB Device Identification

The application uses the QD (Query Device) command in the VNC1L firmware to identify the DLP-TILT device. The VID and PID of each device are compared with the known values for the DLP-TILT module. When a match is found the application uses the SC (Set Current Device) command to select that device. All commands relating to the USB bus are now directed at that device by the VNC1L firmware.

There is an FT232 device on the DLP-TILT module that requires initialisation to 38400 baud before use. The FBD (FTDI Set Baud Rate) command is sent to change the baud rate.

An example of code that can be used to perform this task is shown in Figure 7.1.

```

for (dev = 0; dev < 16; dev++)
{
    // send query device command
    monCmdSendParam(CMD_QD, 1, &dev);
    // read response from query device command
    for (i = 0; i < MON_QD_SIZE; i++)
    {
        qdBuf[i] = monReadWait();
    }
    if (monPrompt() == Resp_Prompt_OK)
    {
        // check VID is same as DLT-TILT
        if ((qdBuf[MON_QD_VID ] == (DLP_TILT_VID & 0xff)) &&
            (qdBuf[MON_QD_VID+1] == (DLP_TILT_VID >> 8)))
        {
            // check PID is same as DLT-TILT
            if ((qdBuf[MON_QD_PID ] == (DLP_TILT_PID & 0xff)) &&
                (qdBuf[MON_QD_PID+1] == (DLP_TILT_PID >> 8)))
            {
                // found DLP-TILT - set current to device
                monCmdSendParam(CMD_SC, 1, &dev);
                if (monPrompt() == Resp_Prompt_OK)
                {
                    // set baud on device to 38400 baud
                    param[0] = 0x4e; param[1] = 0xc0; param[2] = 0;
                    monCmdSendParam(CMD_FBD, 3, &param);
                    if (monPrompt() == Resp_Prompt_OK)
                    {
                        // break from for loop
                        state = stReady;
                        break;
                    }
                }
            }
        }
    }
}

```

Figure 7.1 USB Device Identification

7.2 Disk Detection

To determine if a Flash disk is connected and available for use the application can send a single carriage return character. The VNC1L firmware returns a 'No Disk' prompt if a disk is not available. This is shown in the source code in Figure 7.2.

```

// send carriage return
monCmdSend(CMD_CR);
resp = monPrompt();
if (resp == Resp_Prompt_ND)
{
    state = stDiskError;
}
else
{
    state = stReady;
}

```

Figure 7.2 Disk Detection

It is also possible to verify disk VID and PID values using the QD (Query Device) command as shown in Section 7.1. Further information can be obtained about disk geometry, file systems and capacity using the IDD or IDDE (Identify Disk Drive) commands. The free capacity on a disk can be found by calling the FS or FSE (Free Space) commands. The Free Space commands may take a short time to determine the unused space on a disk.

7.3 Sample Request and Sample Read

Data from the accelerometer is sampled using the DSD (Device Send Data) command to request a sample and the DRD (Device Read Data) commands to read the sample results from the module.

The DLP-TILT device will return a single sample of the readings from its X and Y-axis accelerometer when it is sent a lower-case 'z' character. This signals the start of an analogue to digital conversion. When complete the result is available to read from the module.

Due to the nature of the device, not all the data from the reading may be received in the same DRD command by the VNC1L. Therefore it is necessary to retry the DRD command until no data is received. The DRD command will return a CF (Command Failed) status when the DLP-TILT module has no data available. This is not an error response, but an indication that there is no data available.

Code to send a sample command to the DLP-TILT and read the response to a buffer is given in Figure 7.3. A timestamp (milliseconds elapsed since the application was started) and the data received from the DLP-TILT is converted to decimal and stored in the data FIFO buffer separated by commas.

```

// send one byte of data to the DLP-TILT
monCmdSendByteParam(CMD_DSD, 1);
// data to send 'z' - instruction to sample XY reading
monWrite('z');
// wait for response from monitor
resp = monPrompt();
if (resp == Resp_Prompt_CF)
{
    // DRD command failed
    error = errReadDevice;
    break;
}
// write time-stamp of sample to data buffer (in decimal)
bufPush_ConvLong2Decimal(msTick);
// total count of bytes received from DLP-TILT
count = 0;
// read and store accelerometer readings from the DLP-TILT
do
{
    // send command to read data from currently selected device
    monCmdSend(CMD_DRD);
    // response is number of bytes to read followed by a carriage return
    data = monReadWait();
    // ignore carriage return which follows
    monReadWait();
    // store data returned from command
    if (data > 0)
    {
        // add bytes received in this request to total byte count
        count += data;
        for (i = 0; i < data; i++)
        {
            // write data received to buffer separated by commas
            bufPush(',');
            // convert byte to decimal characters
            bufPush_ConvUChar2Decimal(monReadWait());
        }
        // write carriage return
        bufPush(0x0d);
    }
    // get command response Note: DRD returns CF (Command Failed) if the device
    // NAKs which may be caused by no data available
    resp = monPrompt();
    // exit when a CF is received and count > 0
} while ((!count) || (resp != Resp_Prompt_CF));

```

Figure 7.3 Send and Receive Data from Device

7.4 Data Storage

When sampling commences the application opens a data file using the filename generated in Section 6.3. The OPW (Open for Write) command, see Figure 7.4, is used to open the file for writing. The OPW command appends data to the end of an existing file or creates a new file if it does not already exist.

The parameter length for the OPW command is 11 characters since the filename consists of 8 characters in the name and 3 in the extension. In this case, a dot is not required between the name and the extension since the name is 8 characters long.

```
// open file for write
monCmdSendParam(CMD_OPW, 11, filename);
resp = monPrompt();
if (resp != Resp_Prompt_OK)
{
    error = errFileOpen;
    break;
}
writeBlockCount = 0;
```

Figure 7.4 Open File for Write

A variable `writeBlockCount` is used to keep count of the number of bytes written to the file since it was opened. This counter is used to periodically close and reopen the file when a threshold value is reached. While a file is open for writing the VNC1L firmware does not guarantee to update the file information on the disk. Closing and reopening the file will force the VNC1L firmware to update file information on disk.

In this application the threshold value is set to 512 bytes. For low data rate storage the threshold should be low enough ensure that the file information is updated on the disk at an acceptable frequency for the application. Physically, storage on a Flash disk is accessed in blocks of 512 bytes.

Once the data FIFO buffer size reaches a certain size the application will write the contents of data FIFO to the disk using the WRF (Write to File) command - see Figure 7.5.

```
if (bufCount >= DATA_BLOCK_THRESHOLD)
{
    // create parameter for WRF commands
    param[0] = (bufCount>>16)>>8;
    param[1] = bufCount>>16;
    param[2] = bufCount>>8;
    param[3] = bufCount;
    // send WRF command with parameters
    monCmdSendParam(CMD_WRF, 4, param);
    writeBlockCount += bufCount;
    while (bufCount)
    {
        monWrite(bufPop());
    }
    resp = monPrompt();
    if (resp != Resp_Prompt_OK)
    {
        error = errFileWrite;
        break;
    }
}
```

Figure 7.5 Write to File

The parameter sent to the WRF command is the number of bytes. This is a 4-byte (longword) value with the most significant byte sent first. After the command and parameter are sent then the data is sent sequentially to the VNC1L. When the VNC1L has received the number of bytes of data specified in the parameter it will respond with a prompt. There is no need to send a terminating carriage return to signal the end of the data nor can the data transmission be interrupted by the application.


```
// close file if write block size reached
if (writeBlockCount >= WRITE_BLOCK_SIZE)
{
    monCmdSendParam(CMD_CLF, 11, filename);
    resp = monPrompt();
    if (resp != Resp_Prompt_OK)
    {
        error = errFileClose;
        break;
    }
}
```

Figure 7.6 Close File

Figure 7.6 shows the use of the CLF (Close File) command to close the data file when `writeBlockCount` variable reaches the threshold value.

7.5 Data File Format

A typical data file produced by the VLogger application is given in Figure 7.7. The timestamp at the start of each line is in bold face, followed by the x-tilt reading, y-tilt reading and an additional status character.

```
33347, 130, 127, 3
34347, 130, 127, 3
35347, 130, 127, 3
36347, 130, 127, 3
37347, 130, 127, 3
38347, 130, 127, 3
39347, 130, 127, 3
40347, 130, 127, 3
41347, 130, 127, 3
42347, 130, 127, 3
43347, 129, 127, 3
44347, 117, 138, 3
45347, 120, 139, 3
46347, 122, 137, 3
47347, 128, 125, 3
48347, 129, 123, 3
...
```

Figure 7.7 VLogger Data File

Each reading is taken at an average time between samples of 1000ms. Note that the timestamp and the readings have been converted into decimal.

8 VAcq Application

The VAcq application is an extension to the VLogger application and is designed to record data at a higher sample rate. Data stored in a binary format file.

The application verifies that a Flash disk is available on which to store data and waits for a button on the PICDEM 4 module to be pressed before creating a unique filename in a subdirectory on the Flash disk.

After this it will sets-up a timer to sample an Analogue input on the PIC microcontroller every 5ms and store this data in a software controlled buffer, referred to as the data FIFO. The buffer is accessed using `bufPush()` to add data and `bufPop()` to recover data. The number of bytes stored in the buffer is available in the global variable `bufCount`. Sample readings are added to the data FIFO by an interrupt handler for the ADC, allowing the application to write the data straight from this buffer to a file on the disk.

An STEVAL-MKI010V1 MEMS accelerometer from ST Microelectronics was used to provide a single channel analogue input to the PIC microcontroller on channel RA0.

The application note does not cover the specifics of using timers nor performing analogue to digital conversion on the PIC microcontroller.

When the application is ready to commence sampling the LED RB5 will blink approximately once every 2 seconds. If a Flash disk is not detected the LED RB5 will flash rapidly. Button S1 (RA4) is used to start and stop sampling. The LED RB5 will flash slowly when sampling is taking place.

8.1 Disk Detection

To determine if a Flash disk is connected and available for use the application can send a single carriage return character. The VNC1L firmware returns a 'No Disk' prompt if a disk is not available. This is shown in the source code in Figure 8.1.

```
// send carriage return
monCmdSend(CMD_CR);
resp = monPrompt();
if (resp == Resp_Prompt_ND)
{
    state = stDiskError;
}
else
{
    state = stReady;
}
```

Figure 8.1 Disk Detection

8.2 Data Storage

The application opens a data file for writing using the unique filename generated in Section 6.3. The OPW (Open for Write) command is sent, Figure 8.2, to append to the end of an existing file or create a new file if it does not exist.

```
// open file for write
monCmdSendParam(CMD_OPW, 11, filename);
resp = monPrompt();
if (resp != Resp_Prompt_OK)
{
    error = errFileOpen;
    break;
}
writeBlockCount = 0;
```

Figure 8.2 Open File for Write

Data is always written in blocks of 512 bytes. This increases the data transfer rate to the disk by aligning accesses with the block structure of the storage device.

The start of each block contains a 4-byte timestamp of a millisecond counter is written which can be used to detect missing samples. The rest of the block contains 508 bytes of sample data.

The WRF (Write to File) command and code to read from the data FIFO is shown in Figure 8.3.

```

// create parameter for WRF command
param[0] = (WRITE_BLOCK_SIZE>>16)>>8;
param[1] = WRITE_BLOCK_SIZE>>16;
param[2] = WRITE_BLOCK_SIZE>>8;
param[3] = WRITE_BLOCK_SIZE;
// send WRF <WRITE_BLOCK_SIZE>
monCmdSendParam(CMD_WRF, 4, param);
// write start of block timestamp
monWrite((msTick>>16)>>8);
monWrite(msTick>>16);
monWrite(msTick>>8);
monWrite(msTick&0xff);
// take size of timestamp from data block size
writeBlockCount = sizeof(unsigned long);
// write data pending in buffer
while (writeBlockCount < WRITE_BLOCK_SIZE)
{
    if (bufCount)
    {
        monWrite(bufPop());
        ++writeBlockCount;
    }
}
// wait for response from VNC1L at completion of WRF command
resp = monPrompt();
if (resp != Resp_Prompt_OK)
{
    // WRF command failed - something wrong
    error = errFileWrite;
    break;
}

```

Figure 8.3 Write to File

After the 512-byte block has been written the application closes the file to update the file information on the disk. The CLF (Close File) command is shown in Figure 8.4.

```

monCmdSendParam(CMD_CLF, 11, filename);
resp = monPrompt();
if (resp != Resp_Prompt_OK)
{
    error = errFileClose;
    break;
}

```

Figure 8.4 Close File

The application continually loops back and opens the same file for writing again. While it is closing and reopening the file the ADC is still able to add samples to the data FIFO. These will be sent to the data file once the WRF command is called.

8.3 Data File Format

A typical data file produced by the VAcq application is given in Figure 8.5. The timestamp at the start of each 512-byte block is in bold face. Sections of the sample data have been removed for clarity.

Offset	ASCII	Hexadecimal
00000000	..(Q`.....`	00 00 28 51 60 60 60 60 60 60 60 60 60 60 60 60 60 60
00000010	.....`	60 60 60 60 60 60 60 60 60 60 60 60 60 60 60 60
00000020	.....`	60 60 60 60 60 60 60 60 60 60 60 60 60 60 60 60
00000030	.....`	60 60 60 60 60 60 60 60 60 60 60 60 60 60 60 60
...		
000001f0	.....	8a 8a 8a 8b 8b 8b 8b 8b 8a 8a 8a 8a 8a 8a 89 89
00000200	..2G.....	00 00 32 47 89 89 89 89 8a 8a 8a 8a 8a 8a 8a 8a
00000210	.....	8a 8a 8a 8a 8a 8a 8a 8a 8a 8a 8a 8a 8a 8a 8a 8a
00000220	.....	8a 8a 8a 8a 8a 8a 8a 8a 8a 8a 8a 8a 8a 8a 8a 89
00000230	.....	89 89 8a 89 8a 8a 8a 8a 8a 89 89 89 89 88 88 88
...		
000003f0	ZZ[[[[]\]]]^^^	5a 5a 5b 5b 5b 5b 5c 5c 5c 5c 5c 5d 5d 5e 5e 5e
00000400	..<;^^^^^^	00 00 3c 3b 5e 5e 5e 5e 5e 5e 5f 5f 5f 5f 5f 5f
00000410	.....a	5f 5f 60 60 60 60 60 60 60 60 60 60 60 60 61
00000420	aaaaaaaaaabbcc	61 61 61 61 61 61 61 61 61 61 61 62 62 62 63 63
00000430	ccccddddeeffff	63 63 63 63 63 64 64 64 64 65 65 65 66 66 66 66
...		

Figure 8.5 VAcq Data File

Each 512-byte block contains 508 readings at an average time between samples of 5ms. Therefore, each block records samples over a period of 2.54 seconds.

9 Summary

The provided C code for a PIC microcontroller demonstrates how to use the UART Interface, Command Monitor, USB device commands and disk access commands when interfacing with a VNC1L.

The techniques used in this application note are applicable to the whole range of VNC1L-based modules and applications.

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Appendix A - References

The following documents are available from FTDI and other sources for this purpose:

Document Reference	Description
Vinculum Website	The main website for the Vinculum family of USB Host Controllers on the FTDI website http://www.ftdichip.com/
DS_VNC1L-1A	Vinculum Embedded USB Host Controller IC Data Sheet http://www.ftdichip.com/
Microchip Website	The Microchip website describing the PICDEM 4 Demo Board and PIC18F1320 datasheet http://www.microchip.com/

Table A.1 List of references

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Appendix C - Revision History

Revision History

Version 2.00 Initial Release (rev 1.0 not released)

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