USBXPRESS® PROGRAMMER'S GUIDE

Relevant Devices

This application note applies to the following devices:
C8051F32x, C8051F34x, C8051F38x, C8051T32x, C8051T62x, CP2101, CP2102, CP2103, CP2104, CP2105, CP2108, CP2109

1. Introduction

The Silicon Laboratories USBXpress® Development Kit provides a complete host and device software solution for interfacing Silicon Laboratories C8051F32x, C8051F34x, C8051F38x, C8051T32x, and C8051T62x USB MCUs and CP210x communication bridges to the Universal Serial Bus (USB). No USB protocol or host device driver expertise is required. Instead, a simple, high-level Application Program Interface (API) for both the host software and device firmware is used to provide complete USB connectivity.

The USBXpress Development Kit includes Windows device drivers, Windows device driver installer, host interface function library (host API) provided in the form of a Windows Dynamic Link Library (DLL), and device firmware interface function library (C8051F32x, C8051F34x, C8051F38x, C8051T32x, and C8051T62x devices only).

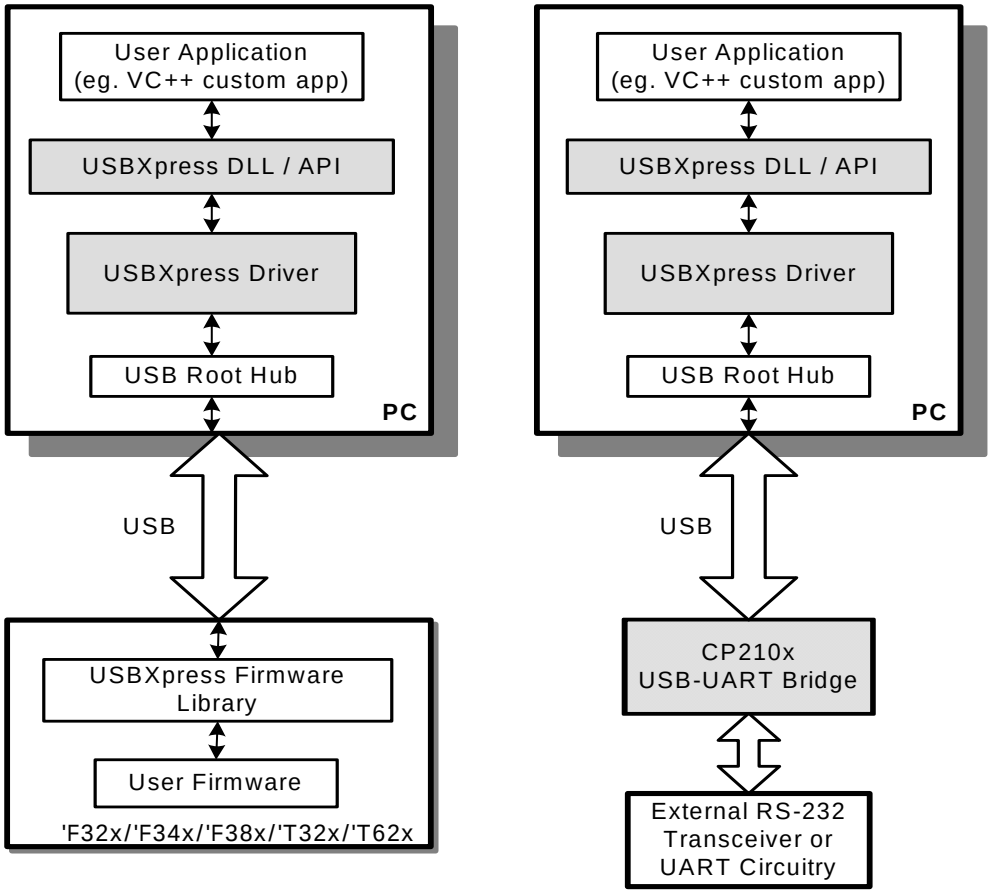


Figure 1. USBXpress Data Flow

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2. USBXpress Versions

The USBXpress v4.0 and above driver incorporates Microsoft's WinUSB driver rather than the proprietary driver of v3.x, and both the underlying driver and the DLL have changed. To use USBXpress v4.0, install the latest driver from the website (www.silabs.com/interface-software) and upgrade the DLL.

The API to the DLL remains unchanged, but there is one new API call added to the library: *SI_CancelIo()*. This API call replaces *CancelIo()* and should be used if the software calls *SI_Read()* or *SI_Write()* in overlapped mode and the software needs to cancel I/O operations. The *SI_CancelIo()* function cancels read and write requests in both the DLL buffer and the driver buffer, whereas *CancelIo()* only cancels requests in the driver buffer, leaving outstanding requests in the DLL.

The AN220 Driver Customization software provides an option to customize either the v4.0 and above driver or the v3.x driver for legacy applications. Customizations of the v4.0 and above WinUSB driver will still require recertification through Microsoft. The AN220 software can be found here: www.silabs.com/interface-appnotes.

3. Host API Functions

The host API is provided in the form of a Windows Dynamic Link Library (DLL). The host interface DLL communicates with the USB device via the provided device driver and the operating system's USB stack. The following is a list of the host API functions available:

```
SI_GetNumDevices()        - Returns the number of devices connected
SI_GetProductString()     - Returns a descriptor for a device
SI_Open()                 - Opens a device and returns a handle
SI_Close()                - Cancels pending IO and closes a device
SI_Read()                 - Reads a block of data from a device
SI_Write()                - Writes a block of data to a device
SI_CancelIo()             - Cancels outstanding overlapped IO
SI_FlushBuffers()         - Flushes the TX and RX buffers for a device
SI_SetTimeouts()          - Sets read and write block timeouts
SI_GetTimeouts ()         - Gets read and write block timeouts
SI_CheckRXQueue()         - Returns the number of bytes in a device's RX queue
SI_SetBaudRate()          - Sets the specified CP210x Baud Rate
SI_SetBaudDivisor()       - Sets the specified CP210x Baud Divisor Value
SI_SetLineControl()       - Sets the CP210x device Line Control
SI_SetFlowControl()       - Sets the CP210x device Flow Control
SI_GetModemStatus()       - Gets the CP210x device Modem Status
SI_SetBreak()             - Sets the Break State for CP210x device.
SI_ReadLatch()            - Gets the port latch value from a CP2103 device
SI_WriteLatch()           - Sets the port latch value to a CP2103 device
SI_GetPartNumber()        - Gets the CP210x device part number
SI_DeviceIOControl()      - Allows sending low-level commands to the device driver
SI_GetDLLVersion()        - Gets the version of the DLL currently in use
SI_GetDriverVersion()     - Gets the version of the USBXpress driver
```

In general, the user initiates communication with the target USB device(s) by making a call to *SI_GetNumDevices*. This call will return the number of target devices. This number is then used as a range when calling *SI_GetProductString* to build a list of device serial numbers or product description strings.

To access a device, it must first be opened by a call to *SI_Open* using an index determined from the call to *SI_GetNumDevices*. The *SI_Open* function will return a handle to the device that is used in all subsequent accesses. Data I/O is performed using the *SI_Write* and *SI_Read* functions. When I/O operations are complete, the device is closed by a call to *SI_Close*.

Additional functions are provided to flush the transmit and receive buffers (*SI_FlushBuffers*), set receive and transmit timeouts (*SI_SetTimeouts*), check the receive buffer's status (*SI_CheckRXQueue*), and miscellaneous device control (*SI_DeviceIOControl*).

For CP210x devices, functions are available to set the baud rate (*SI_SetBaudRate*); set the baud divisor (*SI_SetBaudDivision*); adjust the line control settings such as word length, stop bits, and parity (*SI_SetLineControl*); set hardware handshaking, software handshaking, and modem control signals (*SI_SetFlowControl*); and get modem status (*SI_GetModemStatus*). Additional functions are available for CP2103/4/5/8 devices to get (*SI_ReadLatch*) and set (*SI_WriteLatch*) the values of the additional GPIO pins available on the device. In order to differentiate between CP210x devices, a function (*SI_GetPartNumber*) has been provided to return the part number.

Each of these functions are described in detail in the following sections. Type definitions and constants are defined in "Appendix D—Definitions from C++ header file SiUSBXp.h".

3.1. SI_GetNumDevices

Description: This function returns the number of devices connected to the host.

Supported Devices: C8051F320/1/6/7, C8051F340/1/2/3/4/5/6/7/8/9/A/B/C/D, C8051F380/1/2/3/4/5/6/7, C8051T320/1/2/3/6/7, C8051T620/1/2/3, CP2101/2/3/4/5/8/9/

Prototype: `SI_STATUS SI_GetNumDevices (LPDWORD NumDevices)`

Parameters:

1. *NumDevices*—Address of a DWORD variable that will contain the number of devices connected on return.

Return Value: SI_STATUS = SI_SUCCESS or
SI_DEVICE_NOT_FOUND or
SI_INVALID_PARAMETER

3.2. SI_GetProductString

Description: This function returns a null terminated serial number (S/N) string or product description string for the device specified by an index passed in DeviceNum. The index for the first device is 0 and the last device is the value returned by *SI_GetNumDevices* – 1.

Supported Devices: C8051F320/1/6/7, C8051F340/1/2/3/4/5/6/7/8/9/A/B/C/D, C8051F380/1/2/3/4/5/6/7, C8051T320/1/2/3/6/7, C8051T620/1/2/3, CP2101/2/3/4/5/8/9

Prototype: `SI_STATUS SI_GetProductString (DWORD DeviceNum, LPVOID DeviceString, DWORD Options)`

Parameters:

1. *DeviceNum*—Index of the device for which the product description string or serial number string is desired.
2. *DeviceString*—Variable of type SI_DEVICE_STRING which will contain a NULL terminated device descriptor or serial number string on return.
3. *Options*—DWORD containing flags to determine if DeviceString contains a serial number, product description, Vendor ID, or Product ID string. See "Appendix D—Definitions from C++ header file SiUSBXp.h" for flags.

Return Value: SI_STATUS = SI_SUCCESS or
SI_DEVICE_NOT_FOUND or
SI_INVALID_PARAMETER

3.3. SI_Open

Description: Opens a device (using device number as returned by *SI_GetNumDevices*) and returns a handle which will be used for subsequent accesses.

Supported Devices: C8051F320/1/6/7, C8051F340/1/2/3/4/5/6/7/8/9/A/B/C/D, C8051F380/1/2/3/4/5/6/7, C8051T320/1/2/3/6/7, C8051T620/1/2/3, CP2101/2/3/4/5/8/9

Prototype: `SI_STATUS SI_Open (DWORD DeviceNum, HANDLE *Handle)`

Parameters:

1. *DeviceNum*—Device index. 0 for first device, 1 for 2nd, etc.
2. *Handle*—Pointer to a variable where the handle to the device will be stored. This handle will be used by all subsequent accesses to the device.

Return Value: SI_STATUS = SI_SUCCESS or
SI_DEVICE_NOT_FOUND or
SI_INVALID_PARAMETER or
SI_GLOBAL_DATA_ERROR

3.4. SI_Close

Description: Closes an open device using the handle provided by *SI_Open* and sets the handle to INVALID_HANDLE_VALUE.

Supported Devices: C8051F320/1/6/7, C8051F340/1/2/3/4/5/6/7/8/9/A/B/C/D, C8051F380/1/2/3/4/5/6/7, C8051T320/1/2/3/6/7, C8051T620/1/2/3, CP2101/2/3/4/5/8/9

Prototype: `SI_STATUS SI_Close (HANDLE Handle)`

Parameters:

1. *Handle*—Handle to the device to close as returned by *SI_Open*.

Return Value: SI_STATUS = SI_SUCCESS or
SI_INVALID_HANDLE or
SI_SYSTEM_ERROR_CODE or
SI_GLOBAL_DATA_ERROR

3.5. SI_Read

Description: Reads the available number of bytes into the supplied buffer and retrieves the number of bytes that were read (this can be less than the number of bytes requested). This function returns synchronously if the overlapped object is set to NULL (this happens by default) but will not block system execution. If an initialized OVERLAPPED object is passed then the function returns immediately. If the read completed then the status will be SI_SUCCESS but if I/O is still pending then it will return STATUS_IO_PENDING. If STATUS_IO_PENDING is returned, the OVERLAPPED object can then be waited on using WaitForSingleObject(), and retrieve data or cancel using GetOverlappedResult() (as documented on MSDN by Microsoft) or *SI_CancelIo()* respectively. This functionality allows for multiple reads to be issued and waited on at a time. If any data is available when *SI_Read* is called it will return so check NumBytesReturned to determine if all requested data was returned. To make sure that *SI_Read* returns the requested number of bytes use *SI_CheckRxQueue()* described in Section "3.11. SI_CheckRXQueue" on page 9.

Supported Devices: C8051F320/1/6/7, C8051F340/1/2/3/4/5/6/7/8/9/A/B/C/D, C8051F380/1/2/3/4/5/6/7, C8051T320/1/2/3/6/7, C8051T620/1/2/3, CP2101/2/3/4/5/8/9

Prototype:
```
SI_STATUS SI_Read (HANDLE Handle, LPVOID Buffer, DWORD NumBytesToRead,
DWORD *NumBytesReturned, OVERLAPPED* o = NULL)
```

Parameters:

1. *Handle*—Handle to the device to read as returned by *SI_Open*.
2. *Buffer*—Address of a character buffer to be filled with read data.
3. *NumBytesToRead*—Number of bytes to read from the device into the buffer (0–64 kB).
4. *NumBytesReturned*—Address of a DWORD which will contain the number of bytes actually read into the buffer on return.
5. *(Optional)*—Address of an initialized OVERLAPPED object that can be used for asynchronous reads.

Return Value: SI_STATUS =
SI_SUCCESS or
SI_READ_ERROR or
SI_INVALID_PARAMETER or
SI_INVALID_HANDLE or
SI_SI_READ_TIMED_OUT or
SI_IO_PENDING or
SI_SYSTEM_ERROR_CODE or
SI_INVALID_REQUEST_LENGTH or
SI_DEVICE_IO_FAILED

3.6. SI_Write

Description: Writes the specified number of bytes from the supplied buffer to the device. This function returns synchronously if the overlapped object is set to NULL (this happens by default) but will not block system execution. An initialized OVERLAPPED object may be specified and waited on just as described in the description for *SI_Read()*, Section "3.5. SI_Read" on page 6.

Supported Devices: C8051F320/1/6/7, C8051F340/1/2/3/4/5/6/7/8/9/A/B/C/D, C8051F380/1/2/3/4/5/6/7, C8051T320/1/2/3/6/7, C8051T620/1/2/3, CP2101/2/3/4/5/8/9

Prototype:
```
SI_STATUS SI_Write (HANDLE Handle, LPVOID Buffer, DWORD NumBytesToWrite,
DWORD *NumBytesWritten, OVERLAPPED* o = NULL)
```

Parameters:

1. *Handle*—Handle to the device to write as returned by *SI_Open*.
2. *Buffer*—Address of a character buffer of data to be sent to the device.
3. *NumBytesToWrite*—Number of bytes to write to the device (0–4096 bytes).
4. *NumBytesWritten*—Address of a DWORD which will contain the number of bytes actually written to the device.
5. *(Optional)*—Address of an initialized OVERLAPPED object that can be used for asynchronous writes.

Return Value: SI_STATUS = SI_SUCCESS or
SI_WRITE_ERROR or
SI_INVALID_REQUEST_LENGTH or
SI_INVALID_PARAMETER or
SI_INVALID_HANDLE or
SI_WRITE_TIMED_OUT or
SI_IO_PENDING or
SI_SYSTEM_ERROR_CODE or
SI_DEVICE_IO_FAILED

3.7. SI_Cancello

Description: Cancels any pending IO on a device opened with an OVERLAPPED object.

Supported Devices: C8051F320/1/6/7, C8051F340/1/2/3/4/5/6/7/8/9/A/B/C/D, C8051F380/1/2/3/4/5/6/7, C8051T320/1/2/3/6/7, C8051T620/1/2/3, CP2101/2/3/4/5/8/9

Prototype:
```
SI_STATUS SI_CancelIo (HANDLE Handle)
```

Parameters:

1. *Handle*—Handle to the device to write as returned by *SI_Open*.

Return Value: SI_STATUS = SI_SUCCESS or
SI_INVALID_HANDLE or
SI_SYSTEM_ERROR_CODE or
SI_GLOBAL_DATA_ERROR

3.8. SI_FlushBuffers

Description: On USB MCU devices, this function flushes both the receive buffer in the USBXpress device driver and the transmit buffer in the device. **Note:** Parameter 2 and 3 have no effect and any value can be passed when used with USB MCU devices.
On CP210x devices, this function operates in accordance with parameters 2 and 3. If parameter 2 (FlushTransmit) is non-zero, the CP210x device's UART transmit buffer is flushed. If parameter 3 (FlushReceive) is non-zero, the CP210x device's UART receive buffer is flushed. If parameters 2 and 3 are both non-zero, then both the CP210x device UART transmit buffer and UART receive buffer are flushed.

Supported Devices: C8051F320/1/6/7, C8051F340/1/2/3/4/5/6/7/8/9/A/B/C/D, C8051F380/1/2/3/4/5/6/7, C8051T320/1/2/3/6/7, C8051T620/1/2/3, CP2101/2/3/4/5/8/9

Prototype:
```
SI_STATUS SI_FlushBuffers (HANDLE Handle, BYTE FlushTransmit,
BYTE FlushReceive)
```

Parameters:
1. *Handle*—Handle to the device as returned by *SI_Open*.
2. *FlushTransmit*—Set to a non-zero value to flush the CP210x UART transmit buffer.
3. *FlushReceive*—Set to a non-zero value to flush the receive buffer.

Return Value: SI_STATUS = SI_SUCCESS or
SI_INVALID_HANDLE or
SI_SYSTEM_ERROR_CODE

3.9. SI_SetTimeouts

Description: Sets the read and write timeouts. Timeouts are used for *SI_Read* and *SI_Write* when called synchronously (OVERLAPPED* o is set to NULL). The default value for timeouts is INFINITE (0xFFFFFFFF), but they can be set to wait for any number of milliseconds between 0x0 and 0xFFFFFFFE.

Supported Devices: C8051F320/1/6/7, C8051F340/1/2/3/4/5/6/7/8/9/A/B/C/D, C8051F380/1/2/3/4/5/6/7, C8051T320/1/2/3/6/7, C8051T620/1/2/3, CP2101/2/3/4/5/8/9

Prototype:
```
SI_STATUS SI_SetTimeouts (DWORD ReadTimeout, DWORD WriteTimeout)
```

Parameters:
1. *ReadTimeout—SI_Read* operation timeout (in milliseconds).
2. *WriteTimeout—SI_Write* operation timeout (in milliseconds).

Return Value: SI_STATUS = SI_SUCCESS or
SI_DEVICE_IO_FAILED

3.10. SI_GetTimeouts

Description: Returns the current read and write timeouts. If a timeout value is 0xFFFFFFFF (INFINITE) it has been set to wait infinitely; otherwise the timeouts are specified in milliseconds.

Supported Devices: C8051F320/1/6/7, C8051F340/1/2/3/4/5/6/7/8/9/A/B/C/D, C8051F380/1/2/3/4/5/6/7, C8051T320/1/2/3/6/7, C8051T620/1/2/3, CP2101/2/3/4/5/8/9

Prototype:
```
SI_STATUS SI_GetTimeouts (LPDWORD ReadTimeout, LPDWORD WriteTimeout)
```

Parameters:
1. *ReadTimeout—SI_Read* operation timeout (in milliseconds).
2. *WriteTimeout—SI_Write* operation timeout (in milliseconds).

Return Value: SI_STATUS = SI_SUCCESS or
SI_INVALID_PARAMETER or
SI_DEVICE_IO_FAILED

3.11. SI_CheckRXQueue

Description: Returns the number of bytes in the receive queue and a status value that indicates if an overrun (SI_QUEUE_OVERRUN) has occurred and if the RX queue is ready (SI_QUEUE_READY) for reading. Upon indication of an Overrun condition it is recommended that data transfer be stopped and all buffers be flushed using the *SI_FlushBuffers* command.

Supported Devices: C8051F320/1/6/7, C8051F340/1/2/3/4/5/6/7/8/9/A/B/C/D, C8051F380/1/2/3/4/5/6/7, C8051T320/1/2/3/6/7, C8051T620/1/2/3, CP2101/2/3/4/5/8/9

Prototype:
```
SI_STATUS SI_CheckRXQueue (HANDLE Handle, LPDWORD NumBytesInQueue,
LPDWORD QueueStatus)
```

Parameters:
1. *Handle*—Handle to the device as returned by *SI_Open*.
2. *NumBytesInQueue*—Address of a DWORD variable that contains the number of bytes currently in the receive queue on return.
3. *QueueStatus*—Address of a DWORD variable that contains the SI_RX_EMPTY (also SI_RX_NO_OVERRUN), SI_RX_OVERRUN, or SI_RX_READY flag.

Return Value: SI_STATUS = SI_SUCCESS or
SI_DEVICE_IO_FAILED or
SI_INVALID_HANDLE or
SI_INVALID_PARAMETER

3.12. SI_SetBaudRate

Description: Sets the Baud Rate. Refer to the device data sheet for a list of Baud Rates supported by the device.

Supported Devices: CP2101/2/3/4/5/8/9

Prototype: `SI_STATUS SI_SetBaudRate (HANDLE Handle, DWORD dwBaudRate)`

Parameters:
1. *Handle*—Handle to the device as returned by *SI_Open*.
2. *dwBaudRate*—A DWORD value specifying the Baud Rate to set.

Return Value: SI_STATUS = SI_SUCCESS or
SI_INVALID_BAUDRATE or
SI_INVALID_HANDLE or
SI_INVALID_PARAMETER or
SI_DEVICE_IO_FAILED

3.13. SI_SetBaudDivisor

Description: Sets the Baud Rate directly by using a specific divisor value. This function is obsolete; use *SI_SetBaudRate* instead.

Supported Devices: CP2101/2/3/4/5/8/9

Prototype: `SI_STATUS SI_SetBaudDivisor (HANDLE Handle, WORD wBaudDivisor)`

Parameters:
1. *Handle*—Handle to the device as returned by *SI_Open*.
2. *wBaudDivisor*—A WORD value specifying the Baud Divisor to set.

Return Value: SI_STATUS = SI_SUCCESS or
SI_INVALID_HANDLE or
SI_INVALID_PARAMETER or
SI_DEVICE_IO_FAILED

3.14. SI_SetLineControl

Description: Adjusts the line control settings: word length, stop bits, and parity. Refer to the device data sheet for valid line control settings.

Supported Devices: CP2101/2/3/4/5/8/9

Prototype: `SI_STATUS SI_SetLineControl (HANDLE Handle, WORD wLineControl)`

Parameters:

1. *Handle*—Handle to the device as returned by *SI_Open*.
2. *wLineControl*—A WORD variable that contains the desired line control settings. Possible input settings are as follows:

Bits 0–3	**Number of Stop bits**
0:	1 stop bit;
1:	1.5 stop bits;
2:	2 stop bits

Bits 4–7	**Parity**
0:	None
1:	Odd
2:	Even
3:	Mark
4:	Space

Bits 8–15	**Number of bits per word**
5, 6, 7, or 8	

Return Value: SI_STATUS = SI_SUCCESS or
SI_DEVICE_IO_FAILED or
SI_INVALID_HANDLE or
SI_INVALID_PARAMETER

3.15. SI_SetFlowControl

Description: Adjusts the following flow control settings: set hardware handshaking, software handshaking, and modem control signals. See "Appendix D—Definitions from C++ header file SiUSBXp.h" for pin characteristic definitions.

Supported Devices: CP2101/2/3/4/5/8/9

Prototype:
```
SI_STATUS SI_SetFlowControl (HANDLE Handle, BYTE bCTS_MaskCode,
BYTE bRTS_MaskCode, BYTE bDTR_MaskCode, BYTE bDSRMaskCode,
BYTE bDCD_MaskCode, BYTE bFlowXonXoff)
```

Parameters:

1. *Handle*—Handle to the device as returned by *SI_Open*.
2. *bCTS_MaskCode*—The CTS pin characteristic must be as follows:
   SI_STATUS_INPUT or
   SI_HANDSHAKE_LINE.
3. *bRTS_MaskCode*—The RTS pin characteristic must be as follows:
   SI_HELD_ACTIVE,
   SI_HELD_INACTIVE,
   SI_FIRMWARE_CONTROLLED or
   SI_TRANSMIT_ACTIVE_SIGNAL.
4. *bDTR_MaskCode*—The DTR pin characteristic must be as follows:
   SI_HELD_INACTIVE,
   SI_HELD_ACTIVE or
   SI_FIRMWARE_CONTROLLED.
5. *bDSR_MaskCode*—The DSR pin characteristic must be as follows:
   SI_STATUS_INPUT or
   SI_HANDSHAKE_LINE.
6. *bDCD_MaskCode*—The DCD pin characteristic must be as follows:
   SI_STATUS_INPUT or
   SI_HANDSHAKE_LINE.
7. *bFlowXonXoff*—Sets software flow control to be off if the value is 0, and on using the character value specified if value is non-zero.

Return Value: SI_STATUS = SI_SUCCESS or
SI_DEVICE_IO_FAILED or
SI_INVALID_HANDLE or
SI_INVALID_PARAMETER

3.16. SI_GetModem Status

Description: Gets the Modem Status from the device. This includes the modem pin states.

Supported Devices: CP2101/2/3/4/5/8/9

Prototype: `SI_STATUS SI_GetModemStatus (HANDLE Handle, PBYTE ModemStatus)`

Parameters:

1. *Handle*—Handle to the device as returned by *SI_Open*.
2. *lpbModemStatus*—Address of a BYTE variable that contains the current states of the RS-232 modem control lines. The byte is defined as follows:

Bit 0:	DTR State
Bit 1:	RTS State
Bit 4:	CTS State
Bit 5:	DSR State
Bit 6:	RI State
Bit 7:	DCD State

Return Value: SI_STATUS = SI_SUCCESS or
SI_DEVICE_IO_FAILED or
SI_INVALID_HANDLE or
SI_INVALID_PARAMETER

3.17. SI_SetBreak

Description: Sends a break state (transmit or reset) to a CP210x device. Note that this function is not necessarily synchronized with queued transmit data.

Supported Devices: CP2101/2/3/4/5/8/9

Prototype: `SI_STATUS SI_SetBreak(HANDLE cyHandle, WORD wBreakState)`

Parameters:

1. *Handle*—Handle to the device as returned by SI_Open.
2. *wBreakState*—The break state to set. If this value is a 0x0000 then the break is reset. If this value is a 0x0001 then a break is transmitted.

Return Value: SI_STATUS = SI_SUCCESS or
SI_DEVICE_IO_FAILED or
SI_INVALID_HANDLE or
SI_INVALID_PARAMETER

3.18. SI_ReadLatch

Description: Gets the current port latch value (least significant four bits) from the device.

Supported Devices: CP2103/4/5

Prototype: `SI_STATUS SI_ReadLatch (HANDLE Handle, LPBYTE Latch)`

Parameters:
1. *Handle*—Handle to the device as returned by *SI_Open*.
2. *Latch*—Pointer for a return port latch value (Logic High = 1, Logic Low = 0).

Return Value: SI_STATUS = SI_SUCCESS or
SI_DEVICE_NOT_FOUND or
SI_FUNCTION _NOT_SUPPORTED or
SI_GLOBAL_DATA_ERROR or
SI_INVALID_HANDLE or
SI_INVALID_PARAMETER or
SI_DEVICE_IO_FAILED

3.19. SI_WriteLatch

Description: Sets the current port latch value (least significant four bits) from the device.

Supported Devices: CP2103/4/5

Prototype: `SI_STATUS SI_WriteLatch (HANDLE Handle, BYTE Mask, BYTE Latch)`

Parameters:
1. *Handle*—Handle to the device as returned by *SI_Open*.
2. *Mask*—Determines which pins to change (Change = 1, Leave = 0).
3. *Latch*—Value to write to the port latch (Logic High = 1, Logic Low = 0).

Return Value: SI_STATUS = SI_SUCCESS or
SI_DEVICE_NOT_FOUND or
SI_FUNCTION _NOT_SUPPORTED or
SI_GLOBAL_DATA_ERROR or
SI_INVALID_HANDLE or
SI_INVALID_PARAMETER or
SI_DEVICE_IO_FAILED

3.20. SI_GetPartNumber

Description: Retrieves the part number of the CP210x device for a given handle.

Supported Devices: CP2101/2/3/4/5/8/9

Prototype: `SI_STATUS SI_GetPartNumber (HANDLE Handle, LPBYTE PartNum)`

Parameters:
1. *Handle*—Handle to the device as returned by *SI_Open*.
2. *Latch*—Pointer for a return part number.

Return Value: SI_STATUS = SI_SUCCESS or
SI_INVALID_PARAMETER or
SI_INVALID_HANDLE or
SI_DEVICE_IO_FAILED

3.21. SI_DeviceIOControl

Description: Interface for any miscellaneous device control functions. A separate call to *SI_DeviceIOControl* is required for each input or output operation. A single call cannot be used to perform both an input and output operation simultaneously. Refer to *DeviceIOControl* function definition on MSDN Help for more details.

Supported Devices: C8051F320/1/6/7, C8051F340/1/2/3/4/5/6/7/8/9/A/B/C/D, C8051F380/1/2/3/4/5/6/7, C8051T320/1/2/3/6/7, C8051T620/1/2/3

Prototype:
```
SI_STATUS SI_DeviceIOControl (HANDLE Handle, DWORD IOControlCode,
LPVOID InBuffer, DWORD BytesToRead, LPVOID OutBuffer,
DWORD BytesToWrite, LPDWORD BytesSucceeded)
```

Parameters:

1. *Handle*—Handle to the device as returned by *SI_Open*.
2. *IOControlCode*—Code to select control function.
3. *InBuffer*—Pointer to input data buffer.
4. *BytesToRead*—Number of bytes to be read into InBuffer.
5. *OutBuffer*—Pointer to output data buffer.
6. *BytesToWrite*—Number of bytes to write from OutBuffer.
7. *BytesSucceeded*—Address of a DWORD variable that will contain the number of bytes read by a input operation or the number of bytes written by a output operation on return.

Return Value: SI_STATUS = SI_SUCCESS or
SI_DEVICE_IO_FAILED or
SI_INVALID_HANDLE

3.22. SI_GetDLLVersion

Description: Obtains the version of the DLL that is currently in use. The version is returned in two DWORD values, HighVersion and LowVersion. This corresponds to version A.B.C.D where A = (HighVersion >> 16) & 0xFFFF, B = HighVersion & 0xFFFF, C = (LowVersion >> 16) & 0xFFFF and D = LowVersion & 0xFFFF.

Supported Devices: C8051F320/1/6/7, C8051F340/1/2/3/4/5/6/7/8/9/A/B/C/D, C8051F380/1/2/3/4/5/6/7, C8051T320/1/2/3/6/7, C8051T620/1/2/3, CP2101/2/3/4/5/8/9

Prototype:
```
SI_STATUS SI_GetDLLVersion (DWORD* HighVersion,DWORD* LowVersion)
```

Parameters:

1. HighVersion—Address of a DWORD variable that will contain the top 32 bits of the DLL version.
2. LowVersion—Address of a DWORD variable that will contain the bottom 32 bits of the DLL version.

Return Value: SI_STATUS = SI_SUCCESS or SI_SYSTEM_ERROR_CODE

3.23. SI_GetDriverVersion

Description: Obtains the version of the Driver that is currently in the Windows System directory. The version is returned in two DWORD values, HighVersion and LowVersion. This corresponds to version A.B.C.D where A = (HighVersion >> 16) & 0xFFFF, B = HighVersion & 0xFFFF, C = (LowVersion >> 16) & 0xFFFF and D = LowVersion & 0xFFFF.

Supported Devices: C8051F320/1/6/7, C8051F340/1/2/3/4/5/6/7/8/9/A/B/C/D, C8051F380/1/2/3/4/5/6/7, C8051T320/1/2/3/6/7, C8051T620/1/2/3, CP2101/2/3/4/5/8/9

Prototype: `SI_STATUS SI_GetDriverVersion (DWORD* HighVersion,DWORD* LowVersion)`

Parameters:

1. HighVersion—Address of a DWORD variable that will contain the top 32 bits of the DLL version.
2. LowVersion—Address of a DWORD variable that will contain the bottom 32 bits of the DLL version.

Return Value: SI_STATUS = SI_SUCCESS or SI_SYSTEM_ERROR_CODE

4. Device Interface Functions

The USBXpress firmware library implements a set of device interface functions that provide an Application Programming Interface (API) on the C8051F32x, C8051F34x, C8051F38x, C8051T32x, and C8051T62x microcontrollers. These functions provide a simplified I/O interface to the MCU's USB controller, thus eliminating the need to understand and manage low-level USB hardware or protocol details. The API is provided in the form of a library file precompiled under the Keil C51 tool chain. Device firmware must be developed using the Keil Software C51 tool chain. The device interface functions available are:

`USB_Clock_Start()`	- Initializes the USB clock
`USB_Init()`	- Enables the USB interface
`Block_Write()`	- Writes a buffer of data to the host via the USB
`Block_Read()`	- Reads a buffer of data from the host via the USB
`Get_Interrupt_Source()`	- Indicates the reason for an API interrupt
`USB_Int_Enable()`	- Enables the API interrupts
`USB_Int_Disable()`	- Disables API interrupts
`USB_Disable()`	- Disables the USB interface
`USB_Suspend()`	- Suspends the USB interrupts
`USB_Get_Library_Version()`	- Returns the USBXpress firmware library version

The API is used in an interrupt-driven mode. The user must provide an interrupt handler located at vector address 0x0083 (interrupt 16) for the 'F320/1/6/7 devices, or at vector address 0x008B (interrupt 17) for the 'F34x/'F38x/'T32x/'T62x devices. This handler will be called upon at any USB API interrupt. Once inside this ISR, a call to *Get_Interrupt_Source* is used to determine the source of the interrupt (this call also clears the pending interrupt flags).

The USBXpress firmware library operates the MCU's USB controller at USB Full Speed, and uses the Bulk Transfer type with a data payload of 64 bytes per packet. Code developed for a specific MCU device family ('F320/1, 'F326/7, 'F34x, 'F38x, 'T32x, or 'T62x) must use USBXpress device firmware libraries specific to that family. See "Appendix C—Firmware Library Notes" for more technical details, and differences between the MCU device firmware libraries.

Note: The USB0 hardware interrupt located at vector address 0x0043 (interrupt 8) is claimed by USBXpress, and is used to handle low-level USB protocol details. The USB API interrupt (interrupt 16 for 'F320/1/6/7 devices and interrupt 17 for 'F34x devices) is a virtual interrupt generated by the USBXpress firmware library whenever user code needs to be notified of a USBXpress event. The events are defined in the description of the *Get_Interrupt_Source* function.

Example ISR for Firmware API (interrupt 16 for 'F32x devices, interrupt 17 for 'F34x/'F38x/'T32x/'T62x devices):

```
void USB_API_TEST_ISR(void) interrupt 16
{
   BYTE INTVAL = Get_Interrupt_Source();

   if (INTVAL & TX_COMPLETE)
   {
      Block_Write(In_Packet, 8);
   }

   if (INTVAL & RX_COMPLETE)
   {
      Block_Read(Out_Packet, 8);
   }
```

```
   if (INTVAL & DEV_CONFIGURED)
   {
      // Initialize all analog peripherals here. This interrupt
      // tells the device that it can now use as much current as
      // specified by the MaxPower descriptor.
      Init();           // Note: example command, not part of the API
   }

   if (INTVAL & DEV_SUSPEND)
   {
      // Turn off all analog peripherals
      Turn_Off_All();   // Note: example command, not part of the API

      USB_Suspend();    // This function returns once resume
                        //    signalling is present.

      // Turn all analog peripherals back on
      Init();           // Note: example command, not part of the API
   }
}
```

4.1. USB_Clock_Start

Description: Enables the internal oscillator, initializes the clock multiplier, and sets the USB clock to 48 MHz for USB full speed operation. If the clock multiplier is already initialized, the initialization procedure is skipped. This function should be called before calling *USB_Init* or accessing any variables located in the upper 1024 bytes of XRAM (USB clock domain). CLKSEL[1:0] is not affected by this function. See "Appendix A—SFRs that Should Not be Modified After Calling USB_Clock_Start and USB_Init" for more details. See "Appendix C—Firmware Library Notes" for instructions on how to use the external oscillator as the USB clock.

Supported Devices: C8051F320/1/6/7, C8051F340/1/2/3/4/5/6/7/8/9/A/B/C/D, C8051F380/1/2/3/4/5/6/7, C8051T320/1/2/3/6/7, C8051T620/1/2/3

Prototype: `void USB_Clock_Start (void)`

Parameters: None

Return Value: None

4.2. USB_Init

Description: Enables the USB interface, the USB clock recovery feature, and the use of Device Interface Functions. On return, the USB interface is configured, and C8051F32x interrupts are globally enabled. User software should not globally disable interrupts (set EA = 0), but should enable or disable user configured interrupts individually using the interrupt's source interrupt enable flag present in the IE, EIE1, or EIE2 SFRs. Before calling *USB_Init*, a call to *USB_Clock_Start* should be made to configure the USB clock. See "Appendix A—SFRs that Should Not be Modified After Calling USB_Clock_Start and USB_Init" for more details.

This function allows the user to specify the Vendor and Product IDs as well as Manufacturer, Product Description, and Serial Number strings that are sent to the host as part of the device's USB descriptor during the USB enumeration (device connection).

Supported Devices: C8051F320/1/6/7, C8051F340/1/2/3/4/5/6/7/8/9/A/B/C/D, C8051F380/1/2/3/4/5/6/7, C8051T320/1/2/3/6/7, C8051T620/1/2/3

Prototype:
```
void USB_Init (UINT VendorID, UINT ProductID, BYTE *ManufacturerStr,
BYTE *ProductStr, BYTE *SerialNumberStr, BYTE MaxPower,
BYTE PwAttributes, UINT bcdDevice)
```

Parameters:

1. *VendorID*—16-bit Vendor ID to be returned to the host's Operating System during USB enumeration. Set to 0x10C4 to use the default Silicon Laboratories Vendor ID.
2. *ProductID*—16-bit Product ID to be returned to the host's Operating System during USB enumeration. Set to 0xEA61 to associate with the default USBXpress driver.
3. *ManufacturerStr*—Pointer to a character string. See Appendix B for formatting. NULL pointer should not be used because the library does not contain a default value for this string.
4. *ProductStr*—Pointer to a character string. See Appendix B for formatting. NULL pointer should not be used because the library does not contain a default value for this string.
5. *SerialNumberStr*—Pointer to a character string. See Appendix B for formatting. NULL pointer should not be used because the library does not contain a default value for this string.
6. *MaxPower*—Specifies how much bus current a device requires. Set to one half the number of milliamperes required. The maximum allowed current is 500 milliamperes, and hence any value above 0xFA will be automatically set to 0xFA. Example: Set to 0x32 to request 100 mA.
7. *PwAttributes*—Set bit 6 to 1 if the device is self-powered and to 0 if it is bus-powered. Set bit 5 to 1 if the device supports the remote wakeup feature. Bits 0 through 4 must be 0 and bit 7 must be 1. Example: Set to 0x80 to specify a bus-powered device that does not support remote wakeup.
8. *bcdDevice*—The device's release number in BCD (binary-coded decimal) format. In BCD, the upper byte represents the integer, the next four bits are tenths, and the final four bits are hundredths. Example: 2.13 is denoted by 0x0213.

Return Value: None

4.3. Block_Write

Description: Writes a buffer of data to the host via USB. Maximum block size is 4096 bytes. Returns the number of bytes actually written. This matches the parameter NumBytes unless an error condition occurs. A zero is returned if *Block_Write* is called with NumBytes greater than 4096. If NumBytes is greater than 64 bytes, the Bulk Transaction is split into multiple packets, each with a 64-byte data payload (except last packet). *Block_Write* returns after copying the last packet to the device USB transmit buffer. The completion of the transaction is then indicated by the TX_COMPLETE USB API interrupt.

SI_Read can read from 0 to 64 kB of data. If *Block_Write* is called multiple times before *SI_Read* is called then there is potential to read all of the data in the host's buffer depending on the amount of data requested in the read. For example, if *Block_Write* is called 4 times, and sends a byte of data in each block the host side can call *SI_Read* requesting 4 bytes and get the data from all 4 of the *Block_Writes* at once.

Supported Devices: C8051F320/1/6/7, C8051F340/1/2/3/4/5/6/7/8/9/A/B/C/D, C8051F380/1/2/3/4/5/6/7, C8051T320/1/2/3/6/7, C8051T620/1/2/3

Prototype: `UINT Block_Write (BYTE *Buffer, UINT NumBytes)`

Parameters:
1. *Buffer*—Pointer to a memory location where data to be written is stored.
2. *NumBytes*—Number of bytes to write (1–4096).

Return Value: Returns an unsigned 16-bit value indicating the number of bytes actually written.

4.4. Block_Read

Description: Reads a buffer of data sent from the host via USB. Maximum block size is 64 bytes. The block of data is copied from the USB interface to the memory location pointed to by Buffer. The device USB receive buffer will be emptied on return regardless of whether or not the entire buffer was read by *Block_Read*. The maximum number of bytes to read from the device USB receive buffer is specified in NumBytes. The number of bytes actually read (copied to Buffer) is returned by the function. A zero is returned if there are no bytes to read. Typically, *Block_Read* should be called after receiving a data packet, indicated by an RX_COMPLETE USB API interrupt.

Multiple calls to *Block_Read* might be needed to read all data sent via one *SI_Write* call if the buffer sent to *SI_Write* is more than 64 bytes.

Supported Devices: C8051F320/1/6/7, C8051F340/1/2/3/4/5/6/7/8/9/A/B/C/D, C8051F380/1/2/3/4/5/6/7, C8051T320/1/2/3/6/7, C8051T620/1/2/3

Prototype: `BYTE Block_Read (BYTE *Buffer, BYTE NumBytes)`

Parameters:
1. *Buffer*—Pointer to a memory location where data will be copied.
2. *NumBytes*—Number of bytes to read (1–64).

Return Value: Returns an unsigned 8-bit value indicating the number of bytes actually read.

4.5. Get_Interrupt_Source

Description: Returns an 8-bit value indicating the reason(s) for the API interrupt, and clears the USB API interrupt pending flag(s). This function should be called at the beginning of the user's interrupt service routine to determine which event(s) has/have occurred.

Supported Devices: C8051F320/1/6/7, C8051F340/1/2/3/4/5/6/7/8/9/A/B/C/D, C8051F380/1/2/3/4/5/6/7, C8051T320/1/2/3/6/7, C8051T620/1/2/3

Prototype: `BYTE Get_Interrupt_Source (void)`

Parameters: None

Return Value: Returns an unsigned 8-bit code indicating the reason(s) for the API interrupt. The code can indicate more than one type of interrupt at the same time. The return values are coded as follows:

0x00		No USB API Interrupts have occurred
0x01	USB_RESET	USB Reset Interrupt has occurred
0x02	TX_COMPLETE	Transmit Complete Interrupt has occurred
0x04	RX_COMPLETE	Receive Complete Interrupt has occurred
0x08	FIFO_PURGE	Command received (and serviced) from the host to purge the USB buffers
0x10	DEVICE_OPEN	Device Instance Opened on host side
0x20	DEVICE_CLOSE	Device Instance Closed on host side
0x40	DEV_CONFIGURED	Device has entered configured state
0x80	DEV_SUSPEND	USB suspend signaling present on bus

4.6. USB_Int_Enable

Description: A call to this function enables the USB API to generate interrupts. If enabled, a USB API interrupt is generated on the following API events:

1. A USB Reset has occurred.
2. A transmit scheduled by a call to *Block_Write* has completed.
3. The RX buffer is ready to be serviced by a call to *Block_Read*.
4. A command from the host has caused the USB buffers to be flushed.
5. A Device Instance has been opened or closed by the host.

The cause of the interrupt can be determined by a call to *Get_Interrupt_Source*. If USB API interrupts are enabled, the user must provide an interrupt service routine with the entry point located at the interrupt 16 vector (Address = 0x0083). When this function is called, control will transfer to the interrupt 16 handler within one ms, if any interrupts are currently pending.

Supported Devices: C8051F320/1/6/7, C8051F340/1/2/3/4/5/6/7/8/9/A/B/C/D, C8051F380/1/2/3/4/5/6/7, C8051T320/1/2/3/6/7, C8051T620/1/2/3

Prototype: `void USB_Int_Enable (void)`

Parameters: None

Return Value: None

4.7. USB_Int_Disable

Description: This function disables the USB API interrupt generation.

Supported Devices: C8051F320/1/6/7, C8051F340/1/2/3/4/5/6/7/8/9/A/B/C/D, C8051F380/1/2/3/4/5/6/7, C8051T320/1/2/3/6/7, C8051T620/1/2/3

Prototype: `void USB_Int_Disable (void)`

Parameters: None

Return Value: None

4.8. USB_Disable

Description: This function disables the USB interface and the use of Device Interface Functions. On return, the USB interface is no longer available and API interrupts are turned off. The clock multiplier is turned off to reduce power consumption unless the system clock is set to the '4x Clock Multiplier/2' option (CLKSEL[1:0] = 10b).

Supported Devices: C8051F320/1/6/7, C8051F340/1/2/3/4/5/6/7/8/9/A/B/C/D, C8051F380/1/2/3/4/5/6/7, C8051T320/1/2/3/6/7, C8051T620/1/2/3

Prototype: `void USB_Disable (void)`

Parameters: None

Return Value: None

4.9. USB_Suspend

Description: This function allows devices to meet the USB suspend current specification. To be USB compliant, a USB device must support the Suspend feature by reducing its total power consumption to be under 500 µA. This function should only be called when the DEV_SUSPEND USB API interrupt is received. All unnecessary user peripherals should be turned off before making this function call, and can be turned back on after the call returns. This routine powers down the USB transceiver and the clock multiplier and then suspends the internal oscillator until USB resume signaling occurs. Once USB traffic is detected, internal oscillator is restarted, *USB_Clock_Start* is called, and then the function call returns to user code. **Note:** *USB_Suspend* will set the system clock to internal oscillator by default. If system clock is set to clock multiplier when *USB_Suspend* is called, that setting will be restored before this function returns. If it is necessary to use any other setting for system clock, user code should modify CLKSEL on return from *USB_Suspend*.

Supported Devices: C8051F320/1/6/7, C8051F340/1/2/3/4/5/6/7/8/9/A/B/C/D, C8051F380/1/2/3/4/5/6/7, C8051T320/1/2/3/6/7, C8051T620/1/2/3

Prototype: `void USB_Suspend (void)`

Parameters: None

Return Value: None

4.10. USB_Get_Library_Version

Description: This function returns the USBXpress firmware library version number in BCD. This function is available in USBXpress firmware libraries from release 2.4 and above. Example: Rev. 2.41 is returned as 0x0241.

Supported Devices: C8051F320/1/6/7, C8051F340/1/2/3/4/5/6/7/8/9/A/B/C/D, C8051F380/1/2/3/4/5/6/7, C8051T320/1/2/3/6/7, C8051T620/1/2/3

Prototype: `UINT USB_Get_Library_Version (void)`

Parameters: None

Return Value: Returns the USBXpress firmware library version number as an unsigned 16-bit value in BCD format.

APPENDIX A—SFRS THAT SHOULD NOT BE MODIFIED AFTER CALLING USB_CLOCK_START AND USB_INIT

Supported Devices: C8051F320/1/6/7, C8051F340/1/2/3/4/5/6/7/8/9/A/B/C/D, C8051F380/1/2/3/4/5/6/7, C8051T320/1/2/3/6/7, C8051T620/1/2/3

The following is a list of SFRs configured by the API. These should not be altered at any time after the first call to *USB_Clock_Start* or *USB_Init*. Most of these SFRs are dedicated to the USB peripheral on the chip and should be of no concern to the programmer under most circumstances.

Off-Limits USB SFRs—USB0XCN, USB0ADR, and USB0DAT

Off-Limits Other SFRs—CLKMUL, OSCICN (Only bits 5–7 are off-limits), CLKSEL (Only bits 4–6 are off-limits). These three SFRs are used to enable the internal oscillator, engage the 4x clock multiplier to 48 MHz, and to use that as the clock for the USB core. For the API to function properly, these should not be modified.

API—User Shared SFRs:

The CLKSEL SFR is used for choosing both the system clock source and USB clock source. Care should be used to OR in the system clock desired into Bits 1–0, so as not to disturb Bits 6–4, which are the USB clock selection bits.

The OSCICN SFR is used to control the internal oscillator. The IFCN[1:0] bits can be modified as required by the user to modify the system clock frequency. Note that the IFCN bits do not affect the 12 MHz clock multiplier input or the USB clock. Care should be taken to preserve bits 5–7 while modifying the IFCN bits.

APPENDIX B—FORMAT OF USER-DEFINED PRODUCT DESCRIPTION AND SERIAL NUMBER STRINGS

Supported Devices: C8051F320/1/6/7, C8051F340/1/2/3/4/5/6/7/8/9/A/B/C/D, C8051F380/1/2/3/4/5/6/7, C8051T320/1/2/3/6/7, C8051T620/1/2/3

It is possible for the API to use strings defined and allocated in user firmware instead of the API default strings. The syntax for defining and using custom strings is:

```
unsigned char CustomString[]={number of string elements,0x03,'A',0,'B',0,'C',0...'Z',0};
```

The number of string elements = number of letters x 2 + 2, since every letter needs to be separated from the next by zeros, and USB requires that the first element be the length, and the second element is 0x03, meaning string descriptor type. This sounds harder than it is, for example:

```
//ABC Inc
unsigned char CustomString1[]={16,0x03,'A',0,'B',0,'C',0,' ',0,'I',0,'n',0,'c',0};

//Widget
unsigned char CustomString2[]={14,0x03,'W',0,'i',0,'d',0,'g',0,'e',0,'t',0};

//12345
unsigned char CustomString3[]={12,0x03,'1',0,'2',0,'3',0,'4',0,'5',0};
```

Then, if the Vendor ID and Product ID were 0xABCD and 0x1123, the call to *USB_Init* would be

```
USB_Init (0xABCD, 0x1123, CustomString1, CustomString2, CustomString3);
```

Note: It is useful to use the code keyword preceding the CustomString definitions, so that the strings are located in code space.

APPENDIX C—FIRMWARE LIBRARY NOTES

Supported Devices: C8051F320/1/6/7, C8051F340/1/2/3/4/5/6/7/8/9/A/B/C/D, C8051F380/1/2/3/4/5/6/7, C8051T320/1/2/3/6/7, C8051T620/1/2/3

Tool Chain

The USBXpress Firmware Library has been developed with the Keil C51 Tool Chain, and is distributed as a pre-compiled library. Hence the user project should be built using the Keil C51 tool chain, with the USB_API.LIB included as an external library. A header file USB_API.h with macro definitions and function prototypes is also provided.

Memory-Model Concerns

The firmware API library was created using the small memory model. Using this library in a project with a default memory model of large or compact can cause warnings to occur, depending on warning level settings. To avoid this, set the default memory model to small, and override this setting wherever necessary by defining each function with the large compiler keyword.

The “using” Keyword

The “using” keyword should not be used with the USB API ISR. This compile-time optimization is not supported by the USBXpress library code that is used to create the virtual USB API interrupt (interrupt # 16).

Internal Functions and Variables

All internal function names and global variable names in the USBXpress firmware library begin with the prefix “USBXcore”. To avoid conflict with these PUBLIC symbols that will, if duplicated, result in “MULTIPLE PUBLIC DEFINITIONS” errors, global variables and function names in user firmware should not begin with this prefix.

Using External Oscillator or Clock

By default, USBXpress uses the internal 12 MHz oscillator along with the 4x Clock Multiplier as the USB Clock. To override this, the user firmware can provide its own *USB_Clock_Start* function. The Keil linker will then override the library function with the user-supplied function. If a high precision external crystal or clock is used, you may want to turn off the USB clock recovery feature. To do this, user firmware code should include a dummy function definition as shown below. This will override the corresponding internal function in the library.

```
void USBXcore_ClkRec(void) large { }
```

Saving XDATA Space

The *USB_Init* function parameters are passed in direct memory locations in user XDATA space determined by the linker. If user firmware needs this contiguous space, these 17 bytes can be relocated to unused XDATA space within the USBXpress reserved area. To do this, the following should be added to the command line while invoking the linker (the value for “address” is shown in Table 1):

```
XDATA(?XD?_USB_INIT?USB_API(<address>))
```

Example:
```
BL51.exe file1.obj,file2.obj,fileN.obj,USB_API.LIB TO prj1 RS(256) PL(68) PW(78)XDATA(?XD?_USB_INIT?USB_API(0x03EF))
```

Firmware Library Code Size and Other Details

The Flash memory occupied by the USBXpress firmware library depends on the number of library functions used by the user application. This is because the linker includes only the called functions in the build. If all USBXpress functions are used, the library would occupy ~3 kB of code memory. The low-level settings configured by the USBXpress firmware library are shown in Table 1.

Table 1. Firmware Library Technical Details

	C8051F320/1	C8051F326/7	C8051F340/1/2/3/4/5/6/7/8/9/A/B/C/D
Internal Oscillator[1]	Enabled (OSCICN.7 = 1)		
4x Clock Multiplier[1]	Enabled (Source: Internal Oscillator)		
USB Clock Recovery[1]	Enabled (CLKREC = 0x89)		
USB Clock Source[1]	Clock multiplier (48 MHz)		
USB Speed	Full Speed (12 Mbps)		
USB Transfer Type	Bulk Transfer		
Max data payload size (Control Endpoint, EP0)	64 bytes per data packet		
Number of bulk data endpoints used	2 (EP2 in Split Mode)	2 (EP1 in Split Mode)	2 (EP2 in Split Mode)
Max data payload size (Bulk data endpoints)	64 bytes per data packet		
Double buffering	Enabled for both IN and OUT endpoints (FIFO can hold two packets each at any time).	Enabled for OUT endpoint (FIFO can hold two packets at any time). Disabled for IN endpoint.	Enabled for both IN and OUT endpoints (FIFO can hold two packets each at any time).
XDATA space reserved by the library[2]	448 bytes XDATA (0x0640 to 0x07FF) [includes USB FIFO space]	128 bytes (0x0380 to 0x03FF) XDATA + 256 bytes (0x00 to 0xFF) USB FIFO	448 bytes XDATA (0x0640 to 0x07FF) [includes USB FIFO space]
Starting address to relocate USB_Init function parameters (see " Saving XDATA Space" on page 26)	0x07AF	0x03EF	0x07AF
USBXpress Firmware Library Name	USBX_F320_1.LIB	USBX_F326_7.LIB	USBX_F34X.LIB
	C8051F380/1/2/3/4/5/6/7	**C8051T620/1 and C8051T320/1/2/3**	**C8051T622/3 and C8051T326/7**

Notes:
1. The clock settings listed in this table are valid only if the default USBXpress clock functions (USB_Clock_Start and USBXcore_ClkRec) are not overridden by user firmware.
2. This reserved space includes the relocated USB_Init parameters using linker commands. See " Saving XDATA Space" on page 26 for more details. This only applies to the Keil libraries.

Table 1. Firmware Library Technical Details (Continued)

Internal Oscillator[1]	Enabled (OSCICN.7 = 1)		
4x Clock Multiplier[1]	Enabled (Source: Internal Oscillator)		
USB Clock Recovery[1]	Enabled (CLKREC = 0x8F)		
USB Clock Source[1]	Clock multiplier (48 MHz)		
USB Speed	Full Speed (12 Mbps)		
USB Transfer Type	Bulk Transfer		
Max data payload size (Control Endpoint, EP0)	64 bytes per data packet		
Number of bulk data endpoints used	2 (EP2 in Split Mode)	2 (EP2 in Split Mode)	2 (EP1 and EP2)
Max data payload size (Bulk data endpoints)	64 bytes per data packet		
Double buffering	Enabled for both IN and OUT endpoints (FIFO can hold two packets each at any time).	Enabled for both IN and OUT endpoints (FIFO can hold two packets each at any time).	Enabled for OUT endpoint (FIFO can hold two packets at any time). Disabled for IN endpoint.
XDATA space reserved by the library[2]	448 bytes XDATA (0x0640 to 0x07FF) [includes USB FIFO space]	448 bytes XDATA (0x0640 to 0x07FF) [includes USB FIFO space]	116 bytes (0x038C to 0x03FF) XDATA + 256 bytes (0x0400 to 0x04FF) USB FIFO
Starting address to relocate USB_Init function parameters (see " Saving XDATA Space" on page 26)	0x07AF	0x07AF	0x3EF
USBXpress Firmware Library Name	USBX_F38X.LIB	USBX_T620_1_320_3.LIB	USBX_T622_3_T326_7.LIB

Notes:

1. The clock settings listed in this table are valid only if the default USBXpress clock functions (USB_Clock_Start and USBXcore_ClkRec) are not overridden by user firmware.
2. This reserved space includes the relocated USB_Init parameters using linker commands. See " Saving XDATA Space" on page 26 for more details. This only applies to the Keil libraries.

Type Definitions from Firmware Library Header File USB_API.h

```
// UINT type definition
#ifndef _UINT_DEF_
#define _UINT_DEF_
typedef unsigned int UINT;
#endif  /* _UINT_DEF_ */

// BYTE type definition
#ifndef _BYTE_DEF_
#define _BYTE_DEF_
typedef unsigned char BYTE;
#endif   /* _BYTE_DEF_ */
```

APPENDIX D—DEFINITIONS FROM C++ HEADER FILE SiUSBXP.H

Supported Devices: C8051F320/1/6/7, C8051F340/1/2/3/4/5/6/7/8/9/A/B/C/D, C8051F380/1/2/3/4/5/6/7, C8051T320/1/2/3/6/7, C8051T620/1/2/3, CP2101/2/3/4/5/8/9

```
// Return codes
#define  SI_SUCCESS                    0x00
#define  SI_DEVICE_NOT_FOUND           0xFF
#define  SI_INVALID_HANDLE             0x01
#define  SI_READ_ERROR                 0x02
#define  SI_WRITE_ERROR                0x04
#define  SI_RESET_ERROR                0x05
#define  SI_INVALID_PARAMETER          0x06
#define  SI_INVALID_REQUEST_LENGTH     0x07
#define  SI_DEVICE_IO_FAILED           0x08
#define  SI_INVALID_BAUDRATE           0x09
#define  SI_FUNCTION_NOT_SUPPORTED     0x0a
#define  SI_GLOBAL_DATA_ERROR          0x0b
#define  SI_SYSTEM_ERROR_CODE          0x0c
#define  SI_READ_TIMED_OUT             0x0d
#define  SI_WRITE_TIMED_OUT            0x0e
#define  SI_IO_PENDING                 0x0f

// GetProductString() function flags
#define  SI_RETURN_SERIAL_NUMBER       0x00
#define  SI_RETURN_DESCRIPTION         0x01
#define  SI_RETURN_LINK_NAME           0x02
#define  SI_RETURN_VID                 0x03
#define  SI_RETURN_PID                 0x04

// RX Queue status flags
#define  SI_RX_NO_OVERRUN              0x00
#define  SI_RX_EMPTY                   0x00
#define  SI_RX_OVERRUN                 0x01
#define  SI_RX_READY                   0x02

// Buffer size limits
#define  SI_MAX_DEVICE_STRLEN          256
#define  SI_MAX_READ_SIZE              4096*16
#define  SI_MAX_WRITE_SIZE             4096

// Type definitions
typedef  int      SI_STATUS;
typedef  char     SI_DEVICE_STRING[SI_MAX_DEVICE_STRLEN];




// Input and Output pin Characteristics
```

```
#define  SI_HELD_INACTIVE              0x00
#define  SI_HELD_ACTIVE                0x01
#define  SI_FIRMWARE_CONTROLLED        0x02
#define  SI_RECEIVE_FLOW_CONTROL       0x02
#define  SI_TRANSMIT_ACTIVE_SIGNAL     0x03
#define  SI_STATUS_INPUT               0x00
#define  SI_HANDSHAKE_LINE             0x01

// Mask and Latch value bit definitions
#define  SI_GPIO_0                     0x01
#define  SI_GPIO_1                     0x02
#define  SI_GPIO_2                     0x04
#define  SI_GPIO_3                     0x08

// GetDeviceVersion() return codes
#define  SI_CP2101_VERSION             0x01
#define  SI_CP2102_VERSION             0x02
#define  SI_CP2103_VERSION             0x03
#define  SI_CP2104_VERSION             0x04
#define  SI_CP2105_VERSION             0x05

// Common variable and type definitions used
typedef unsigned long                  DWORD;
typedef int                            BOOL;
typedef unsigned char                  BYTE;
typedef unsigned short                 WORD;
typedef BYTE near                      *PBYTE;
typedef DWORD near                     *PDWORD;
typedef DWORD far                      *LPDWORD;
typedef void far                       *LPVOID;
```

APPENDIX E—ERROR CODE EXPLANATIONS AND DEBUGGING

Supported Devices: C8051F320/1/6/7, C8051F340/1/2/3/4/5/6/7/8/9/A/B/C/D, C8051F380/1/2/3/4/5/6/7, C8051T320/1/2/3/6/7, C8051T620/1/2/3, CP2101/2/3/4/5/8/9

SI_SUCCESS

The function succeeded.

SI_DEVICE_NOT_FOUND

The device cannot be found on the system. Make sure the device is plugged in and powered. If the device is plugged in, make sure that all previous application handles to the device have been closed (*SI_Close*). If a previous instance of the application was not able to close its handle to the device before exiting, disconnect and reconnect the device. To avoid having to temporarily remove the device in this case, you may have your application store the current handle value (returned by *SI_Open*) in the Windows registry so that if the application crashes, the handle is still accessible and can be closed (*SI_Close*).

SI_INVALID_HANDLE

The value of the Handle passed to the function is not valid. A valid handle is obtained by declaring a HANDLE variable in your program and passing the address of that HANDLE to the *SI_Open* function. A Handle may become invalid if the device is removed from the system, so first verify that the device is connected.

SI_WRITE_ERROR

The write operation failed. The device may have been removed.

SI_INVALID_PARAMETER

An invalid parameter was passed to the DLL function called. See the function definition for valid parameter types and/or ranges.

SI_INVALID_REQUEST_LENGTH

See *SI_Read* and *SI_Write* function descriptions for valid request lengths.

SI_DEVICE_IO_FAILED

Device IO operation failed. The device may have been removed.

SI_INVALID_BAUDRATE

See the CP210x device-specific data sheet for supported baud rates.

SI_FUNCTION_NOT_SUPPORTED

The function called is not supported by the device. For example, attempting to use the *SI_ReadLatch* and *SI_WriteLatch* functions on a device other than the CP2103 will cause the functions to return this value.

SI_GLOBAL_DATA_ERROR

An error has occurred such that the thread global data cannot be retrieved. Unload and reload the DLL if this return code is received.

SI_SYSTEM_ERROR_CODE

Call GetLastError (Win32 Base) to retrieve Windows System Error Code. The error codes are defined on MSDN.

SI_READ_TIMED_OUT or SI_WRITE_TIMED_OUT

The read or write request timed out based on the current timeout values.

SI_IO_PENDING

I/O is pending, wait on the OVERLAPPED object supplied to the *SI_Read* or *SI_Write* function using *WaitForSingleObject()* or *GetOverlappedResult()* as documented on MSDN by Microsoft, and/or *SI_CancelIo()*.

APPENDIX F—UPDATING HOST CODE TO WORK UNDER USBXPRESS 3.X.X

Note: The USBXpress 3.X.X package works different functionally from previous versions (2.42 and earlier). Do not mix and match any of these old DLLs or Drivers with any part of the 3.X.X package. This will result in data error and possibly a system crash.

The SI_Close() function has changed from SI_Close(&HANDLE Handle) to SI_Close(HANDLE Handle). Versions before 3.X.X would set the HANDLE value to INVALID_HANDLE_VALUE when a close was called. Now it is the responsibility of the developer to set the handle value to be invalid. For Visual Basic users, this change will also require a Declare statement modification. The correct way to call this function in VB is:

```
Public Declare Function SI_Close Lib "SiUSBXp.DLL" _
        (ByVal cyHandle As Long) As Integer
```

The Read and Write functions have changed to include a parameter for a pointer to an initialized OVERLAPPED object. For C++ users the prototype has been set so that this parameter is false by default allowing older code to be ported directly. For VB users the Declare statements will have to be updated as follows:

```
Public Declare Function SI_Read Lib "SiUSBXp.DLL" _
        (ByVal cyHandle As Long, ByRef lpBuffer As Byte, _
        ByVal dwBytesToRead As Long, ByRef lpdwBytesReturned As Long, _
        ByVal lpOverlapped As Long) As Integer

Public Declare Function SI_Write Lib "SiUSBXp.DLL" _
        (ByVal cyHandle As Long, ByRef lpBuffer As Byte, _
        ByVal dwBytesToWrite As Long, ByRef lpdwBytesWritten As Long, _
        ByVal lpOverlapped As Long) As Integer
```

DOCUMENT CHANGE LIST

Revision 1.6 to Revision 1.7

- Updated all Host API information to reflect 3.X.X changes. See "Appendix F—Updating Host Code to Work Under USBXPRESS 3.X.X" for important compatibility information.
- Device API documentation:
  - Updated description in "3. Device Interface Functions" to reflect support for 'F326/7 and 'F34x devices.
  - Added description of function "3.10. USB_Get_Library_Version".
  - Updated Table 1 to show details of the 'F326/7 and 'F34x device firmware libraries.

Revision 1.7 to Revision 1.8

- Modified return values for SI_Write.
- Modified descriptions of blocking in SI_Write/ SI_Read.
- Further explained the Block_Write in relation to SI_Read.

Revision 1.8 to Revision 1.9

- Modified return values for SI_Read.
- Removed references to unused return code SI_RX_QUEUE_NOT_READY
- Modified to explain SI_GetDLLVersion and SI_GetDriverVersion

Revision 1.9 to Revision 2.0

- Updated functions return values in "3. Host API Functions" on page 3.
- Corrected prototype declaration for "3.5. SI_Read" on page 6 and "3.6. SI_Write" on page 7.

Revision 2.0 to Revision 2.1

- Added CP2104 and CP2105 to Relevant Devices on Page 1.
- Updated Host API functions to reflect support for CP2104 and CP2105 devices.

Revision 2.1 to Revision 2.2

- Added support for C8051F38x, C8051T32x, and C8051T62x devices.

Revision 2.2 to Revision 2.3

- Added support for CP2108 and CP2109.
- Updated CancelIo() to SI_CancelIo() and added the SI_CancelIo() API information.
- Added "2. USBXpress Versions" on page 2.
- Updated XDATA space reserved by the library for C8051F326/7, C8051T622/3, and C8051T326/7 in Table 1 on page 27.
- Updated Note 2 in Table 1 on page 27.

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