

# Adding SDIO Wi-Fi Solution to i.MX Windows CE 5.0/Windows CE 6.0

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## 1 Introduction

Wi-Fi, which stands for wireless fidelity, is a wireless networking technology used across the globe. Wi-Fi can connect to the Internet within the range of the wireless network connected to the Internet. Therefore, with the wireless communication and Internet, the Wi-Fi improves the customer's experience with the electronics appliances, and hence, it has become more attractive and accepted by the world.

This application note describes the following:

- Main characteristics that should be taken into consideration when selecting a Wi-Fi solution that meets the requirements
- Common requirements that the Wi-Fi solution manufacturer should provide to integrate its solution into the platforms
- Method the Wi-Fi solution driver is integrated into the WinCE™ Board Support Packages (BSP).

### Contents

1. Introduction . . . . .	1
2. Wi-Fi Solution . . . . .	2
3. Selection of Wi-Fi Solution . . . . .	2
4. Integration of Wi-Fi Solution into i.MX WinCE BSPs	4
5. Suggested Tests . . . . .	5
6. Common Errors . . . . .	7
7. Revision History . . . . .	9

## 2 Wi-Fi Solution

The Wi-Fi solution is an external device that is configured and operated by other devices (i.MX) through a common interface and protocol. The Wi-Fi solution has some parts of the Wi-Fi specifications embedded into the silicon and is capable of connecting with other Wi-Fi compliant devices, as access points and routers.

## 3 Selection of Wi-Fi Solution

The following features should be taken into account while searching for a suitable Wi-Fi solution for an application:

- Specifications that include the following:
  - Throughput
  - Output power
  - Low power modes
  - Network authentications
  - Data encryptions
- Recognized brand
- Support model
- Communication interfaces
- Drivers for the operating system (WinCE, Linux™)
- Norms

### 3.1 Specifications

It is important to define the common use case for the final product and determine the minimal requirements for the Wi-Fi solution to which final product should comply.

#### 3.1.1 Throughput

Throughput is a measure of the maximum speed that the Wi-Fi solution device transmits data in a period of time, normally in seconds. Throughput gives the amount of information that the final product needs to transmit/receive. Generally, this metric is taken in the Wi-Fi communication that uses the Transmission Control Protocol (TCP) to send/receive big files and take measures during the transmission and reception. In busy networks, the reception throughput is larger than the transmission throughput.

#### NOTE

The throughput value is normally taken in an ideal environment—that is without noise and obstacles.

### 3.1.2 Output Power

Output power is generally measured in dBm and determines the maximum connection distance from the access point to the device. There are other factors that affect the maximum distance—obstacles, humidity, noise, and so on. These factors can be controlled by correctly locating the radio frequency paths in the Printed Circuit Board (PCB) and selecting an accurate antenna and output amplifier.

It is important to define an accurate output power, as it gives the distance to the access point. Also, it is important to mention the output power, as it varies directly with the power consumption and inversely with the battery life.

### 3.1.3 Low Power Modes

Applications with Wi-Fi capability are usually hand-held and have specific requirements for low power consumption. In these cases, verify if the selected Wi-Fi solution is compliant with the low power requirements—power consumption in sleep mode, run mode, doze mode, and so on. Also, it is important to know the way to turn OFF and send the Wi-Fi solution to sleep mode.

### 3.1.4 Network Authentications

It is important to identify if the Wi-Fi solution supports the connection authentication needed for the application. These network authentications are related to the ability to connect with secure and unsecure networks. An unsecure network, also called an open network, does not require any type of authentication. A secure network is for networks that require defined keys for connection.

The Wi-Fi solution should support the necessary authentication settings that the application requires, such as:

- Wired Equivalent Privacy (WEP)—64/128 bits
- Wi-Fi Protected Access (WPA)
- WPA2

### 3.1.5 Data Encryptions

Another feature that is used and supported by the Wi-Fi solution is the data encryption. After connecting with the access point, the communication can be encrypted through a data encryption setting that is configurable in the Wi-Fi solution.

The data encryption options are as follows:

- WEP
- Cisco™ Key Integrity Protocol (CKIP)

## 3.2 Support Model

Knowledge of the support model of the Wi-Fi solution maker is important, as it can impact the cost of the product (if the support is very expensive) and the time to the market (if the support has priority).

### 3.3 Communication Interfaces

Knowledge on the communication interfaces in the Wi-Fi solution device is important, as they should be compatible with the communication interfaces in the i.MX. The Wi-Fi solution generally supports Secure Digital Input/Output (SDIO) communication. When an SDIO device is selected, it is important to consider the voltage compatibility between the i.MX SDIO interface and Wi-Fi SDIO interface.

### 3.4 Drivers for Operating System

The Wi-Fi device manufacturer should provide the drivers for WinCE 5.0 or 6.0, depending on the operating system used and the instructions to install the operating system into the WinCE image.

### 3.5 Norms

Verify if the selected Wi-Fi solution is compliant with the international norms required for the end product, depending on the target market (medical, automotive, home, industrial, and so on).

Some of the important norms, depending on the target market are as follows:

- Lead-free (Pb-free)
- Federal Communications Commission (FCC)
- Mexican National Standards (NOM)
- Underwriters Laboratories (UL)
- European Conformity (CE)
- Joint Electron Devices Engineering Council (JEDEC)

## 4 Integration of Wi-Fi Solution into i.MX WinCE BSPs

The minimal information and/or files required for the Wi-Fi solution device to operate over the i.MX WinCE BSPs are as follows:

- Wi-Fi solution specific driver that operates for the operating system—It should be compatible with the standard Secure Digital Host Controller (SDHC) driver supplied by the BSPs for the platforms. In some cases, the BSQUARE SDIO bus driver is used between the Wi-Fi solution specific driver and SDHC driver.
- Windows registry configuration specifications—It is used to configure the Wi-Fi solution drivers. The registry specifications are applicable to the file, platform.reg.
- Files such as libraries (dlls files), executable files, test files, configuration files, and so on—To include the files specified by the Wi-Fi solution manufacturer in the image, the lines with the filename and startup allocation should be added to the file, platform.bib.
- Instructions to include the Wi-Fi solution driver into the Catalog Items > View (optional).
- Dependences in the Catalog Items > View.

Read the documentations included with the Wi-Fi software package (Readme.txt, help files, quick start guides, and so on). These documents give detailed information about the implementation of Wi-Fi solution driver into the i.MX BSPs.

There is some code specific to the actual hardware implementation (Wi-Fi–Wi-Fi card power supply, init/reset pin, dectec pin). In the integration process, this code must be added to the Power Management IC (PMIC) driver code or SDHC driver code.

## 5 Suggested Tests

The following tests show a suggested way to test the communication with the Wi-Fi solution device. Here, the Wi-Fi solution device is connected to a SDHC port as the SDIO device and a Serial Peripheral Interface (SPI) port is connected for the control of Wi-Fi solution device.

### 5.1 Test for Serial Communication SPI

The test is described in the following items:

- Requirements:
  - Board with the i.MX and SPI MOSI, MISO, SCLK, and SS paths to connect to the oscilloscope probe
  - Oscilloscope
- Assumptions:
  - The board is powered ON, and the user can download NK images
- Development:
  - a) Develop a test program that opens the selected SPI port and sends data in an infinite loop to a specific slave.
  - b) Build the image, download it into the board, and execute.
  - c) Verify using the oscilloscope probe if the MOSI path has the signal/data in the path, the SCLK path has the clock, and the selected SS path is asserted. To avoid possible problems, refer to [Section 6, “Common Errors.”](#)
- Success criteria:

The test is successful if signal/data in the MOSI path and clock in the SCLK path are observed and the signal in the selected SS path is correct.

### 5.2 Logical Test for Serial Communication SPI

The test is described in the following items:

- Requirements:
  - Board with the i.MX
- Assumptions:
  - The board is powered ON, and the user can download NK images
- Development:
  - a) Configure the SPI driver in the port selected for the loop back control mode. This configuration makes an internal connection between the transmission path and the reception path of the SPI bus.

- b) Develop a test program that opens the selected SPI port, sends data through it, and waits to receive the data sent by polling or interrupts with a time-out. The send and receive process can be in an infinite loop.
  - c) Insert a breakpoint or add print debug instructions in the reception process for success and time-out.
  - d) Build the image, download it into the board, and execute.
  - e) Verify if the system stops in the breakpoint instruction or the Debug window shows the specified print information for success. To avoid possible problems, refer to [Section 6, “Common Errors.”](#)
- Success criteria:  
The test is successful if the system stops in the breakpoint instruction or the Debug window shows the specified print information.

### 5.3 Test for Wi-Fi Solution Device Control Communication through SPI

The test is described in the following items:

- Requirements:
  - Board with the i.MX and Wi-Fi solution connected through the SPI and SDIO ports with the SPI MOSI, MISO, SCLK, and SS paths to connect to the oscilloscope probe
  - Oscilloscope
  - Test commands defined by the Wi-Fi solution device in the specification
- Assumptions:
  - The board is powered ON, and the user can download NK images
- Development:
  - a) Develop a test program that opens and configures the selected SPI port, sends the test command defined in the Wi-Fi solution specification, and waits for a valid response into the time-out window.

#### NOTE

The test commands can include tests for the SDIO communication with the i.MX.

The send and receive process can be in an infinite loop.

- b) Put a breakpoint or add print debug instructions in the reception process for success and time-out.
- c) Build the image, download it into the board, and execute.
- d) Verify with the oscilloscope probes if the MOSI, MISO, SCLK, and SS paths have signal/data in the path.
- e) Verify if the system stops in the breakpoint instruction or the Debug window shows the specified print information for success. To avoid possible problems, refer to [Section 6, “Common Errors.”](#)

- Success criteria:  
The test is successful if signal is observed in the MOSI, MISO, SCLK, and SS paths and the system stops in the breakpoint instruction or the Debug window shows the specified print information.

## 5.4 Test for Wi-Fi Solution

The test is described in the following items:

- Requirements:
  - Board with the i.MX and Wi-Fi solution connected through the SPI port and SDIO port, respectively.
  - A Wi-Fi device or access point in the near field.
- Assumptions:
  - The board is powered ON and has flashed the WinCE image with the Wi-Fi driver.
- Development:
  - a) Turn ON the board, open the Control Panel/Network Connections, and verify the presence of the icon associated with the Wi-Fi communication that configures the Dynamic Host Configuration Protocol (DHCP) or static IP. The icon associated to the Wi-Fi solution is described in the Wi-Fi solution documentation, provided by the Wi-Fi solution vendor.
  - b) In the start bar, an icon, normally two PCs, is present. Double clicking on this displays a window showing the information about the connection, the available wireless networks, and the option to manually configure the wireless network.
  - c) Select and configure the desired wireless network. The i.MX board should be connected to the network, and the icon in the start bar should show the PCs as operating.
  - d) Verify if the Wi-Fi operates as required and specified by the Wi-Fi solution device and Wi-Fi device documentation. It can be easily verified by pinging from/to the i.MX board to/from another Wi-Fi device or access point. In both the cases, these should be connected to the same wireless network.
- Success criteria:  
The test is successful if no issues are observed.

## 6 Common Errors

This section gives the common errors and their solutions when a Wi-Fi solution is integrated into the i.MX BSPs.

## 6.1 Absence of Traffic in SPI MOSI or Clock in SCLK Path or Configuration Signal in SS Path

Consider a case where the developer creates a WinCE test program for the SPI that opens the SPI port, configures it, and sends the data in an infinite while loop.

Three possible issues related to this case are as follows:

- Mismatch between the WinCE SPI port and physical SPI port, and the developer trying to use the WinCE SPI port incorrectly
- SPI port configured with pins that are not used by the hardware
- Custom board swaps the MOSI/MISO SPI paths

Each of these issues are described in the following sections.

### 6.1.1 Mismatch between WinCE SPI Port and Physical SPI Port

This problem occurs when the BSP uses the SPI port numbers that correspond to other physical SPI port numbers. To verify the physical SPI port associated to the WinCE SPI port, check for the key, HKEY\_LOCAL\_MACHINE\Drivers\BuiltIn\CSPIn, in the platform.reg file and look for the Index sub-key registry entry inside the key. Index is found in the i.MX device Reference Manual associated with the specific SPI port of the device. From this information, it can be determined if the WinCE SPIn port corresponds to the i.MX SPI port.

Determine the SPIn port used to communicate with the WiFi solution device. In the Windows registry configuration, verify if the keys related to the WiFi solution driver have been configured to use the correct SPIn port.

### 6.1.2 SPI Port Configured with Pins not used by Hardware

Some modules in the i.MX devices, such as SPI and UART ports, have two or more sets of pins in the device. The sets of pins that are to be used by the WinCE SPI driver are hard configured by the software in the low level drivers. This means that the WinCE SPI driver must be updated if it uses pins other than the pins that are used by the evaluation boards when the BSPs are tested.

This problem exists when the hardware team selects a specific set of pins (for easy layout, easy map, and so on) for the module that are not the default set of pins for the driver. For SPI, this issue can be solved by updating the bspcspi.c file and the function, BSPCSPISetIOMux. This function receives the parameter as the index for the SPI to be configured. The user should check the SPI to be configured in the switch, and configure the correct set of pins. More information about the name of the pins and their alternative function for the SPI are described in the i.MX Reference Manual.

### 6.1.3 Custom Board Swaps the MOSI/MISO SPI Paths

This problem occurs when an inexperienced hardware team maps the SPI paths in a custom board and swaps the MOSI and MISO lines. This can be confirmed by using the WinCE test applications that opens the SPI port and sends data in an infinite loop. Check using an oscilloscope if the MOSI path does not show any signal and the MISO paths shows the data.



The solution to this issue requires reworking the board swapping the MOSI and MISO paths and updating the schematic correctly from the origin of the issues for future releases.

## 6.2 Traffic in SPI Lines but Wi-Fi Solution not Recognized by WinCE

Consider a case where the WinCE program tries to establish the communication with the Wi-Fi solution device through test communication messages defined by the Wi-Fi solution device or through a production application.

Three possible issues related to this problem are as follows:

- Mismatch between the WinCE SPI port configuration and Wi-Fi solution SPI configuration
- Wi-Fi solution not in operational mode
- Erratum in the module of SPI or SDHC

Each of these issues are described in the following sections.

### 6.2.1 Mismatch between WinCE SPI Port Configuration and Wi-Fi Solution SPI Configuration

Verify if the SPI configuration (baud rate, master, slave, chip selects, DMA) in the WinCE and Wi-Fi solutions device specifications are compatible. Confirm with an oscilloscope if the frequency in the SCLK path corresponds to the frequency configured in the SPI configuration registers.

### 6.2.2 Wi-Fi Solution not in Operational Mode

Verify if the Wi-Fi solution power levels are according to the Wi-Fi solution specification and the reset pin does not reset the Wi-Fi solution device when not needed.

#### NOTE

In operational mode, the reset pins should be high.

### 6.2.3 Erratum in Module of SPI or SDHC

Refer to the errata file associated to the device to verify if the issue is related to an identified issue in the device and the related work around to solve the issue.

## 7 Revision History

Table 1 provides a revision history for this application note.

Table 1. Document Revision History

Rev. Number	Date	Substantive Change(s)
0	04/2010	Initial release.

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