ATWINC15x0 Throughput Measurement using iPerf

Introduction

This application note demonstrates execution of the demo iPerf application available for the SAM4S Xplained Pro evaluation kit and ATWINC15x0. The iPerf application is a tool which is used for measuring Transmission Control Protocol (TCP) and User Datagram Protocol (UDP) bandwidth performance. This iPerf tool is built on a client/server model and can be used to measure maximum UDP and TCP throughput between the client and the server station.

Prerequisites

The following are the hardware and software prerequisites to test the TCP and UDP throughput using the iPerf application for the ATWINC15x0.

Hardware Prerequisites

- ATSAM4S XPRO Board
- ATWINC15x0
- Access Point (AP)
- PC/Laptop

Software Prerequisites

- iPerf application 2.0.5 for iPerf client running on PC/Laptop
- Serial console software (Tera Term)
- ATWINC1500 iPerf Example

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1. ATWINC15x0 iPerf Setup

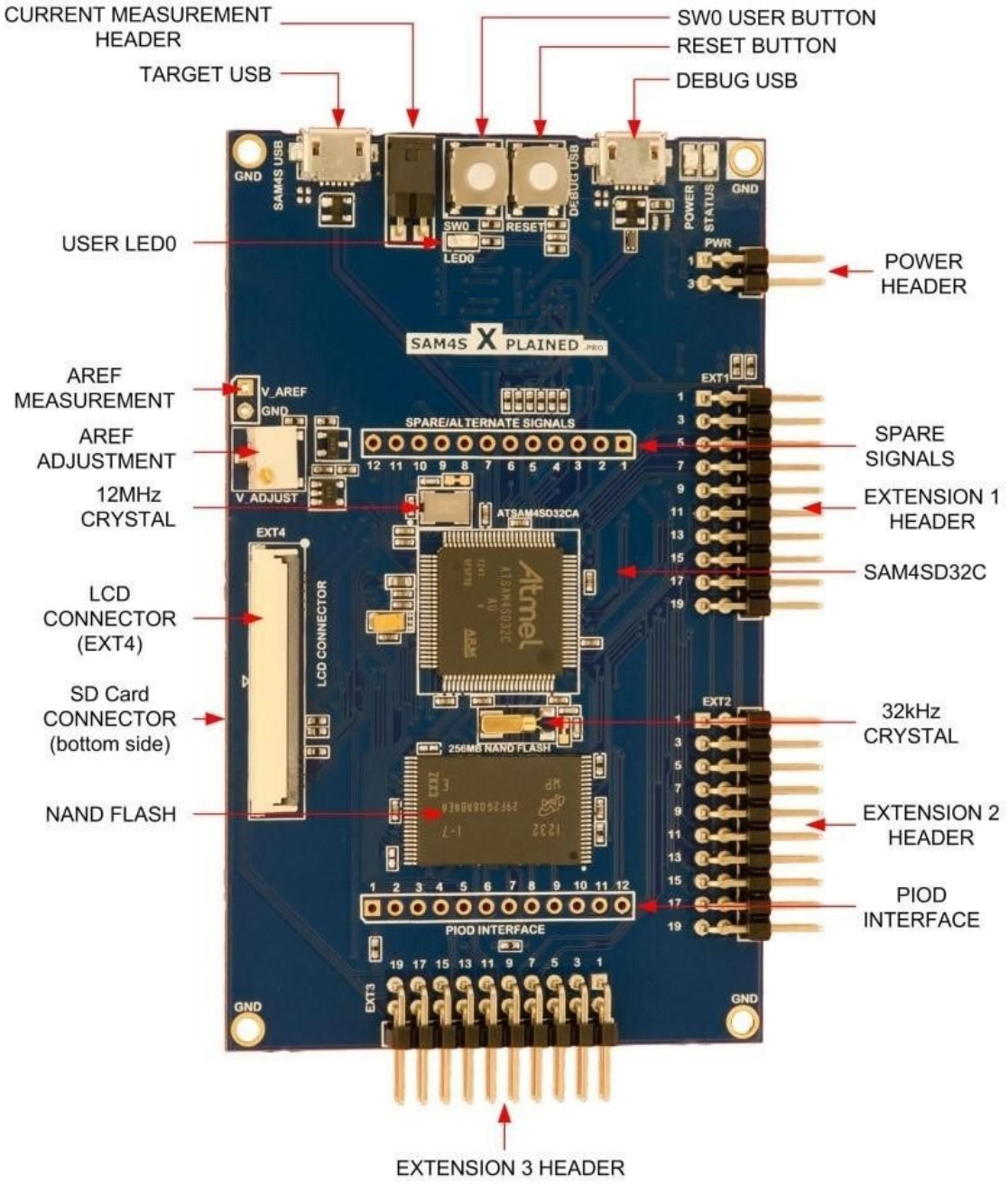
The user can run the iPerf application using the command prompt on a computer and the customized iPerf implementation on the wireless board to measure the throughput performance. The iPerf application contains both client and server functionality. Typically, one acts as server and the other as client, where the iPerf application in the client side launches the test session.

The iPerf application running in the ATSAM4S XPRO board operates in the Server mode and waits to accept the client's connection before it initiates the bandwidth test.

1.1 SAM4S Xplained Pro

The SAM4S Xplained Pro evaluation kit is a hardware platform to evaluate the ATSAM4SD32C microcontroller, supported by the Atmel Studio integrated development platform. The SAM4S Xplained Pro evaluation kit is ideal for evaluation and prototyping with the SAM4S Cortex®-M4 processor-based microcontroller. The Xplained Pro MCU series evaluation kits include an on-board Embedded Debugger, and no external tools are necessary to program or debug the SAM4SD32C. The Xplained Pro extension series evaluation kit offers additional peripherals to extend the features of the board and ease the development of custom designs.

Figure 1-1. SAM4S Xplained Pro Evaluation Kit



1.2 Hardware Setup

Perform the following steps to create the iPerf setup.

1. Plug the ATWINC15x0 module to the EXT1 of the SAM4S Xplained Pro evaluation kit.
2. Power-up the SAM4S Xplained Pro evaluation kit by connecting the USB cable to the DEBUG USB port.

2. Creating ATWINC15x0 iPerf Project in Atmel Studio

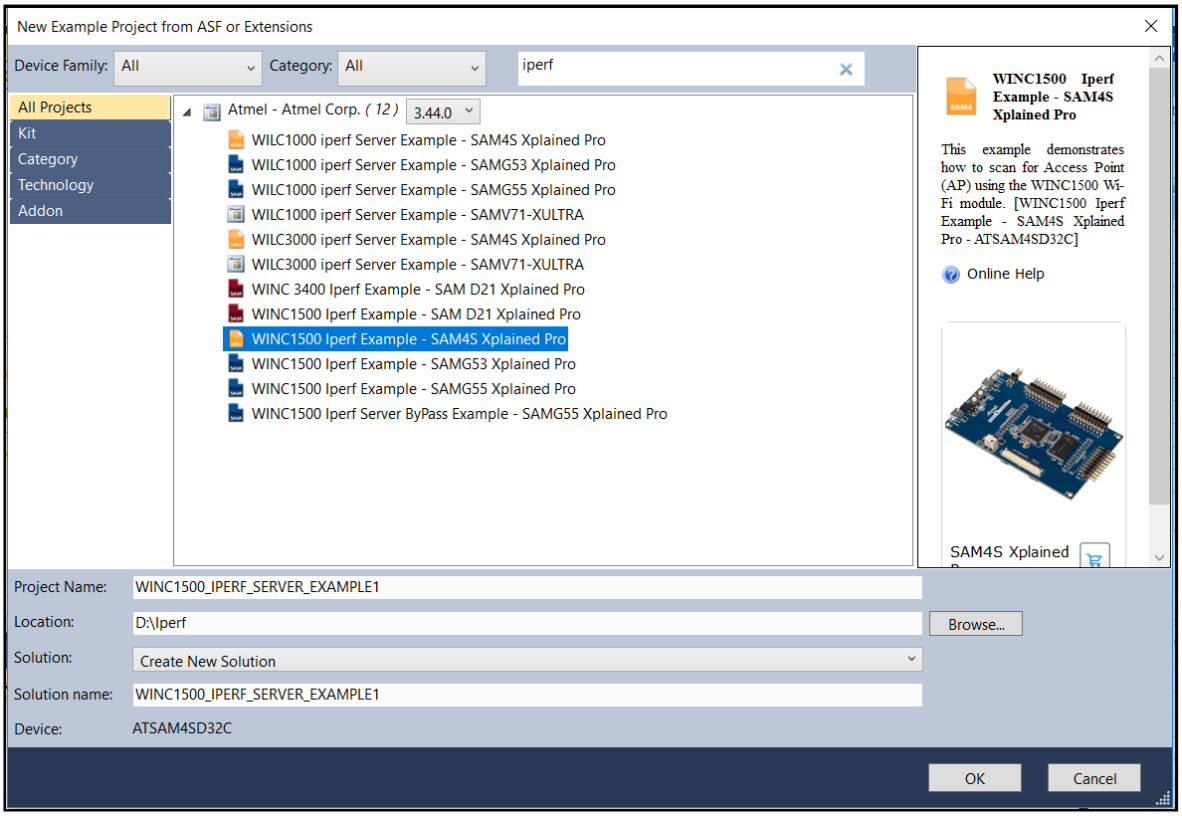
The demo iPerf application for the SAM4S Xplained Pro with the ATWINC15x0 is available in ASF Version 3.42 and all upcoming versions. Before creating a new iPerf project, verify the version of both the ATWINC1500 driver and firmware being used. The ATWINC1500 firmware version needs to be equal or higher to its driver version. The firmware upgrade details are detailed in the Appendix.

This section explains the steps for demonstrating ATWINC15x0 projects using Atmel Studio ASF example applications.

Note: The iPerf application for SAM4S, SAMG55, SAMG53, and SAMD21 is available in ASF. In this Application Note, iPerf application for the SAM4S is used as a reference.

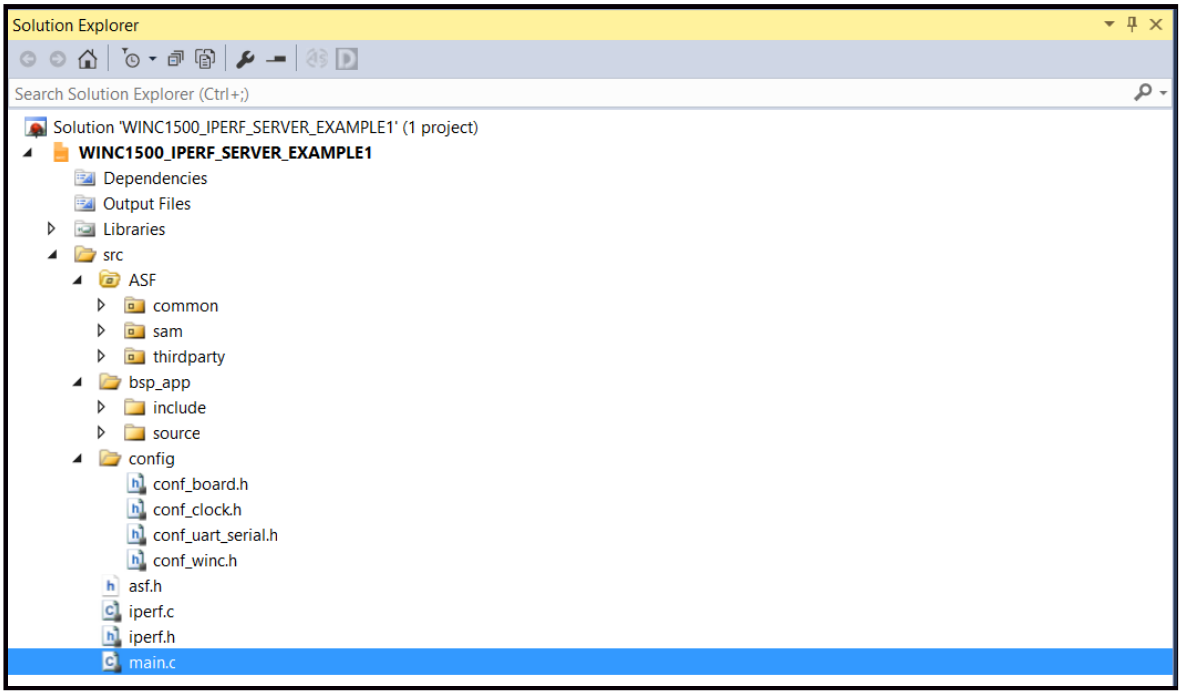
1. Open Atmel Studio 7.
2. Navigate to *File>New>Example Projects*.
3. Search for iperf sample application for other MCU's.
4. Select the WINC1500 Iperf Example – SAM4S Xplained Pro.

Figure 2-1. Atmel Studio ATWINC1500 Project Creation



The directory structure for iPerf application is illustrated in following figure.

Figure 2-2. iPerf Application Directory Structure



3. Configuring and Loading the iPerf Application

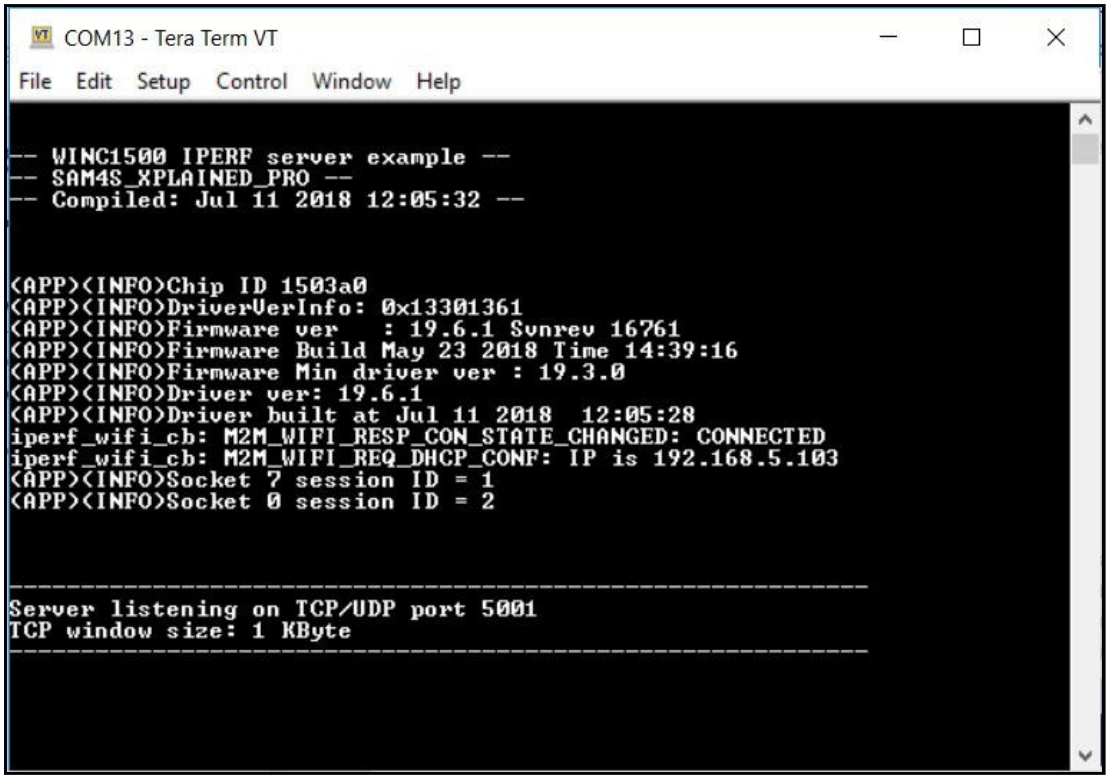
To connect to the access point, the Station mode requires the Wi-Fi credentials, such as SSID and Security type. For this demo, WPA-PSK is used as an example. The following are the steps to configure and load the iPerf application.

1. Open the **WINC1500_IPERF_SERVER_EXAMPLE1** project.
2. Configure the AP credentials; SSID and password in the `iperf.h` file.
   Configure the AP based on the supported security methods.

   To set a security type, in the `iperf.h` file configure `IPERF_WIFI_M2M_WLAN_AUTH` macro as mentioned. The corresponding AP's SSID must be filled with `IPERF_WIFI_M2M_WLAN_SSID` macro as given.

   ```
   /* AP configuration parameters*/
   #define IPERF_WIFI_M2M_WLAN_SSID    "DEMO_APP"/**< Destination SSID */
   #define IPERF_WIFI_M2M_WLAN_AUTH    M2M_WIFI_SEC_WPA_PSK /**< Security manner */
   #define IPERF_WIFI_M2M_WLAN_PSK     "12345678"/**< Password for Destination  SSID */
   ```
3. Save the project.
4. Compile and download the image into the SAM4S board.
5. Open the serial port terminal application, and set the COM port configuration as follows:
   - Set **Baudrate** as **115200**
   - Set **Data Bits** as **8** bit
   - Set **Parity** as **none**
   - Set **Stop Bits** as **1** bit
   - Set **Flow control** as **none**
6. Run the application. The serial port terminal displays the following log output.

Figure 3-1. iPerf Serial Console Initial Log Output



Note: iPerf initializes as UDP/TCP iPerf server.

The IP address assigned to the ATWINC15x0 is available in the serial terminal.

4. Installing iPerf Application

The iPerf application is available as an open source or executable binaries for many operating systems.

The following are the steps to install the iPerf application.

1. Download the iPerf 2.0.5 application from https://iperf.fr/ and save in the desired location.
2. Unzip the downloaded file to get the executable file.
3. Open command prompt in the folder path where this executable file is located.

4.1 iPerf Commands

By default, iPerf clients open a connection with the iPerf server which is typically listening at port 5001 at specified destination. The commonly used iPerf commands are listed in the following table. For additional commands, see https://iperf.fr/iperf-doc.php.

Table 4-1. iPerf Commands

Command	Description
`-f`	Format to report; Kbits, Mbits, KBytes, and MBytes.
`-i`	Interval between periodic bandwidth reports in seconds.
`-s`	Runs in the Server mode.
`-u`	Runs in the single threaded UDP mode and specific to client.
`-b`	Bandwidth to send in bits/sec. `-u` indicates the default value as 1 Mbit/sec.
`-c`	Runs in the client mode, connecting to host.
`-r`	Individual bidirectional test.
`-t`	Time in seconds to transmit. The default value is 10 secs.

5. Executing iPerf Application

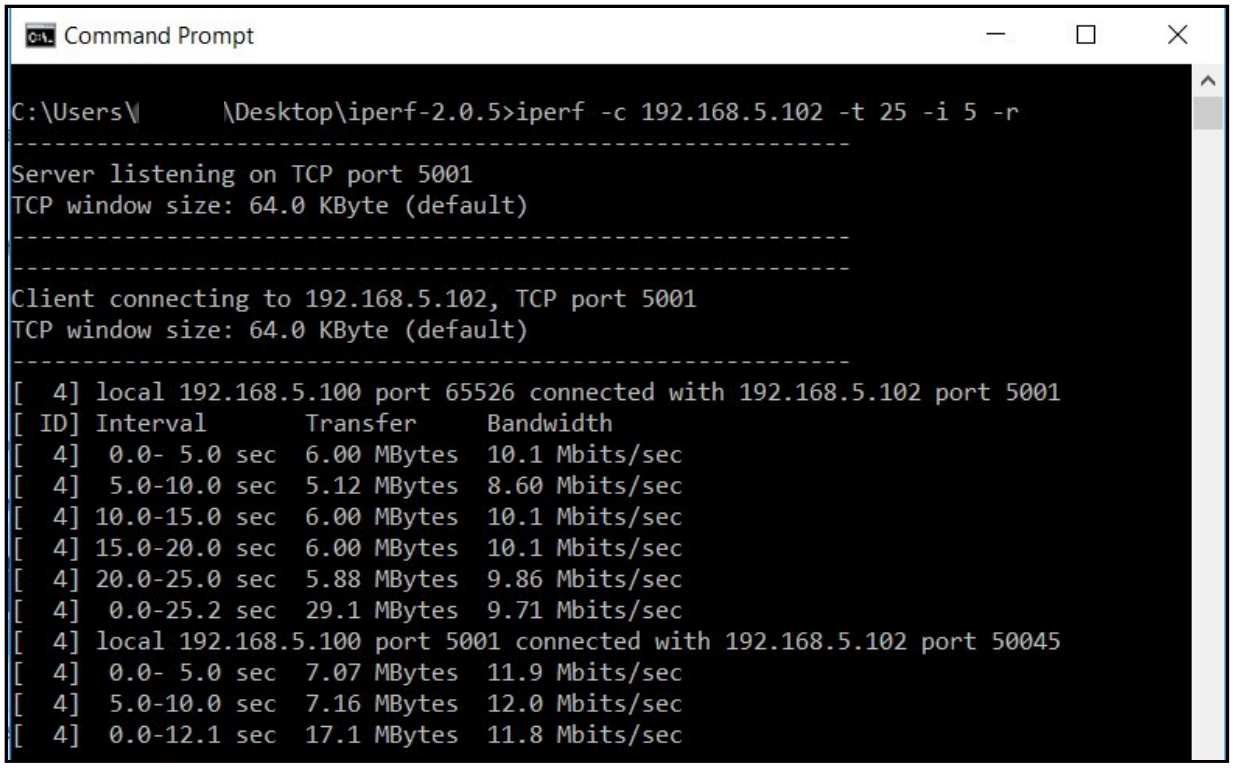
The iPerf application can be executed by configuring one system as client and the other as server. The iPerf application in ASF can work both as server and client. The demo application running in the SAM4S Xplained Pro evaluation kit works in the Server mode and waits to accept the client's connection before initiating the bandwidth test. The client needs to know the IP address of the target server and communicates with the iPerf server located at the specified IP address.

For example, the server with IP address 192.168.1.100 can be run with the TCP test, using the following command:

```
iperf -c 192.168.1.100 -t 20 -i 1 -r
```

- `-t` is time in seconds to transmit (default 10 secs)
- `-i` is the interval between periodic bandwidth reports in seconds
- `-r` on the client's command line instructs iPerf to measure bi-directional throughput sequentially, that is, upstream and downstream

Figure 5-1. Log Output

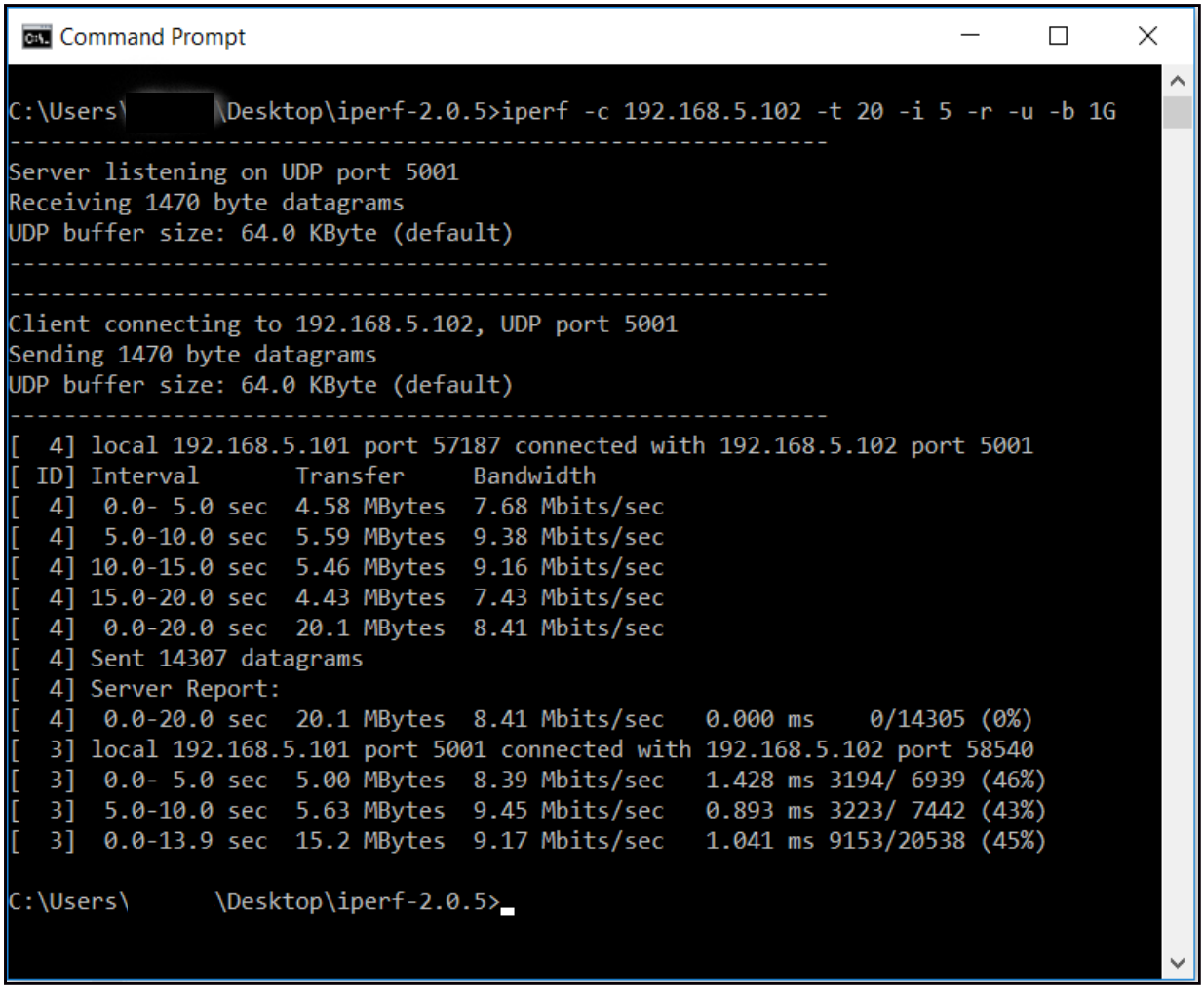


To run the UDP test, add two additional arguments as shown in the following:

```
iperf -c 192.168.1.100 -t 20 -i 1 -u -b 1G
```

- `u` indicates single_udp run in single threaded UDP mode
- `b` indicates bandwidth to send in bits/sec

Figure 5-2. Log Output

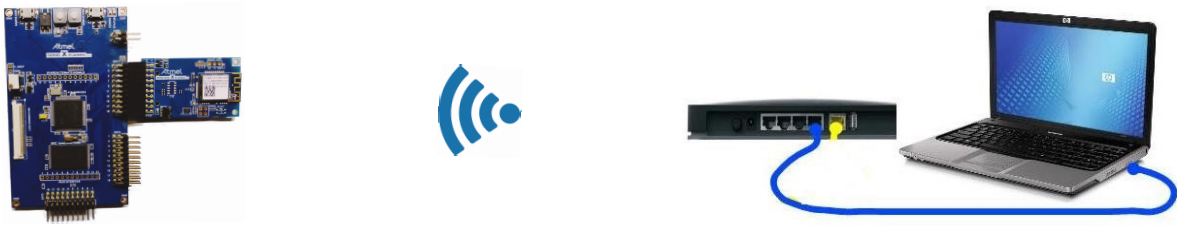


6. Test Setup

The iPerf application testing is not limited to any specific test setup. To observe the variation in throughput results, tests are carried out in different test setups and results are captured as following.

- Setup 1 – PC is connected via Ethernet to AP and ATWINC15x0 is connected via Wi-Fi to AP.

  Figure 6-1. Setup 1

  For test result, see 7. Test Results.

- Setup 2 – Both PC and ATWINC15x0 are connected to AP via Wi-Fi.

  Figure 6-2. Setup 2

  For test result, see 7. Test Results.

  Note: The throughput results measured in setup 2 will be comparatively lower. The aim of this test setup is to show an alternate method to measure the throughput. To achieve better results, follow the setup 1.

- Setup 3 – AP mode.
  In the AP mode, the ATWINC15x0 acts as a SoftAP and provides the provision for other device to connect to it and assigns IP address to the connected device.

  Figure 6-3. Setup 3

  For test result, see 7. Test Results.

The iPerf throughput varies as per the configuration. To record the maximum achievable throughput, the test is conducted in different environments. To observe the variation in throughput, tests are carried out by varying configuration and security methods. This test setup is repeated with different wireless modes b/g/n.

To regulate the throughput value, configuration changes are made only with setup 1. This test results can be taken as a reference and similar changes in throughput can be expected in other modes which have different environments.

The ATWINC15x0 iPerf throughput performance is measured in the following conditions.

Table 6-1. Conditions to Measure ATWINC15x0 iPerf Throughput Performance

Condition	Parameters
Firmware configuration	• Security: Open, WPA. WPA2, and Enterprise • DMA Enabled • DMA Disabled • SPI communication frequency 48 MHz/ 20MHz
Environment	• Inside shielded box • Two setups in shield box (same frequency) • Open air (Moderate, Extreme)
AP configuration	b/g/n

6.1 Throughput Test Result Dependency Parameters

6.1.1 Direct Memory Access

The Direct Memory Access (DMA) can transfer data between memories and peripherals, and off-load these tasks from the CPU. Therefore, DMA enables high data transfer rates with minimum CPU intervention and frees-up CPU time.

By default, Direct Memory Access (DMA) is enabled for the demo iPerf application. The DMA is implemented in the application using `CONF_WINC_SPI_DMA_ENABLE` macro. This macro is implemented in the `conf_winc` file in the configuration folder.

To disable the DMA, comment out the `CONF_WINC_SPI_DMA_ENABLE` macro definition.

6.1.2 SPI Communication Frequency

Varying the SPI communication frequency also has a direct impact in the throughput values. The SPI frequency can be changed using the macro defined in the `conf_winc.h`.

By default, the SPI frequency is set to 48 MHz.

```
/** SPI clock. */
#define CONF_WINC_SPI_CLOCK             (48000000)
```

6.1.3 Security Method

By default, the iPerf application is configured to be secured with WPA/WPA2 personal (PSK). The security method is configured in the `iperf.h` file.

6.1.3.1 Open

To change the security method to OPEN, perform the following.

1. In `iperf.h` file, assign `M2M_WIFI_SEC_OPEN` enum for the `IPERF_WIFI_M2M_WLAN_AUTH` macro instead of `M2M_WIFI_SEC_WPA_PSK` enum.

```
/** Wi-Fi Settings */
#define IPERF_WIFI_M2M_WLAN_SSID            "DEMO_AP" /**< Destination SSID */
#define IPERF_WIFI_M2M_WLAN_AUTH            M2M_WIFI_SEC_OPEN /**< Security manner */
#define IPERF_WIFI_M2M_WLAN_PSK             "12345678" /**< Password for Destination
SSID */
```

2. Call the `m2m_wifi_connect` API as follows.

```
/* Connect to router. */
m2m_wifi_connect((char *)IPERF_WIFI_M2M_WLAN_SSID, sizeof(IPERF_WIFI_M2M_WLAN_SSID),
IPERF_WIFI_M2M_WLAN_AUTH, NULL, M2M_WIFI_CH_ALL);
```

3. Perform similar changes in the AP settings.

6.1.3.2 WPA/WPA2

To change the security method to WPA/WPA2, perform the following.

1. In `iperf.h` file, assign `IPERF_WIFI_M2M_WLAN_AUTH` macro as `M2M_WIFI_SEC_WPA_PSK` enum.

```
/** Wi-Fi Settings */
#define IPERF_WIFI_M2M_WLAN_SSID            "DEMO_AP" /**< Destination SSID */
#define IPERF_WIFI_M2M_WLAN_AUTH            M2M_WIFI_SEC_WPA_PSK /**< Security manner */
#define IPERF_WIFI_M2M_WLAN_PSK             "12345678" /**< Password for Destination
SSID */
```

2. Call the `m2m_wifi_connect` API as follows.

```
/* Connect to router. */
m2m_wifi_connect((char *)IPERF_WIFI_M2M_WLAN_SSID, sizeof(IPERF_WIFI_M2M_WLAN_SSID),
IPERF_WIFI_M2M_WLAN_AUTH, (char *)IPERF_WIFI_M2M_WLAN_PSK, M2M_WIFI_CH_ALL);
```

3. Perform similar changes in the AP settings.

6.1.3.3 Enterprise

To change the security method to Enterprise, perform the following.

1. Modify `MAIN_WLAN_802_1X_USR_NAME`, `MAIN_WLAN_802_1X_PWD` to the name and password, respectively.
2. Modify `MAIN_WLAN_DEVICE_NAME` to wireless network name.
3. Call the `m2m_wifi_connect` API as follows.

```
/* Enterprise Network */
m2m_wifi_connect((char *)IPERF_WIFI_M2M_WLAN_SSID, sizeof(IPERF_WIFI_M2M_WLAN_SSID),
M2M_WIFI_SEC_802_1X,(char *)&gstrCred1x, M2M_WIFI_CH_ALL);
```

4. Perform similar changes in the AP settings.

7. Test Results

A reference of the iperf throughput performance based on the ATWINC15x0 for the different test setups are as follows.

- Setup 1 – One side on Ethernet and ATWINC15x0 on Wi-Fi (Inside shielded room)
- Setup 2 – Both PC and ATWINC15x0 are connected to AP via Wi-Fi
- Setup 3 – AP mode

Note: The values captured in the following table can vary with varying testing conditions.

Table 7-1. iPerf Throughput Performance for TCP and UDP - Setup 1

Environment	SPI Frequency (MHz)	DMA	Channel	Mode	Security		Protocol			
							TCP		UDP	
							Uplink (Mbits/sec)	Downlink (Mbits/sec)	Uplink (Mbits/sec)	Downlink (Mbits/sec)
Shielded Room	20	Yes	6	n	Open		3.51	11.0	9.68	12.5
	48	Yes	6	n	Open		9.71	11.8	13.0	19.5
	48	No	6	n	Open		1.37	6.26	5.95	6.26
	48	Yes	6	n	WPA2	AES	9.9	11.1	12.2	19.3
						AES+TKIP	10	11.4	12.7	19.2
	48	Yes	6	n	WPA	AES	9.85	11.5	12.3	19.2
						TKIP	9.47	10.6	12.9	19.7
	48	Yes	6	n	Enterprise		7.18	12.4	11.7	19.2
	48	Yes	6	g	Open		9.54	11.7	13.3	19.6
	48	Yes	6	g	WPA2	AES	10	11.3	12.3	19.3
						AES+TKIP	9.5	11.3	12.8	19.2
	48	Yes	6	b	Open		4.42	5.01	6.0	6.5
	48	Yes	6	b	WPA2	AES	10	11.4	12.8	19.2
						AES+TKIP	9.74	11.2	12.8	19.6
Open Air (Moderate condition)	48	Yes	6	n	Open		7.75	8.28	12.6	11.0
Open Air (Extreme condition)	48	Yes	6	n	Open		5.73	5.60	10.8	11.2

Table 7-2. iPerf Throughput Performance for TCP and UDP - Setup 2

Environment	SPI Frequency (MHz)	DMA	Channel	Mode	Security	Protocol			
						TCP		UDP	
						Uplink (Mbits/sec)	Downlink (Mbits/sec)	Uplink (Mbits/sec)	Downlink (Mbits/sec)
Shielded Room	48	Yes	6	n	Open	5.03	6.06	7.83	8.35

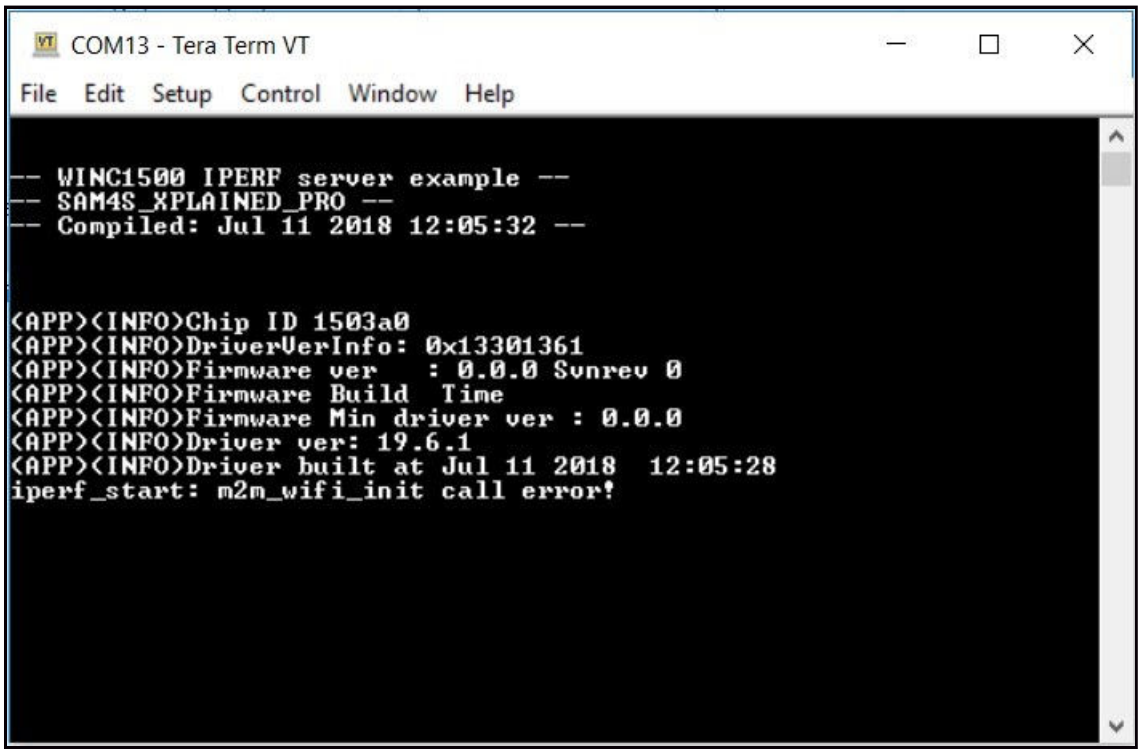
Table 7-3. iPerf Throughput Performance for TCP and UDP - Setup 3

Environment	SPI Frequency (MHz)	DMA	Channel	Mode	Security	Protocol			
						TCP		UDP	
						Uplink (Mbits/sec)	Downlink (Mbits/sec)	Uplink (Mbits/sec)	Downlink (Mbits/sec)
Shielded Room	48	Yes	6	n	Open	9.84	9.81	12.5	18.8

8. Appendix - Updating Firmware

The ATWINC15x0 firmware must be updated to 19.6.1 version or latest. When a version mismatch is detected at start-up, the Wi-Fi driver initialization fails and the `m2m_wifi_init()` function returns the firmware version mismatch error code.

Figure 8-1. Firmware Mismatch Error



To update the firmware in the ATWINC15x0 module, use the firmware upgrade project available in ASF. For more details on the firmware upgrade procedure, refer the Integrated Serial Flash and Memory Download Procedure Application Note.

9. Document Revision History

Revision	Date	Section	Description
A	12/2018	Document	Initial revision

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