

# User Manual

## DA16200 MQTT Programmer Guide

UM-WI-010

### Abstract

*This MQTT Programmer Guide intends to assist software developers that implement applications with the DA16200 SDK. A certain degree of reader familiarity with programming environments, debugging tools, and software engineering process in general is assumed.*

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## Contents

<b>Abstract</b> .....	<b>1</b>
<b>Contents</b> .....	<b>2</b>
<b>Figures</b> .....	<b>3</b>
<b>Tables</b> .....	<b>3</b>
<b>Terms and Definitions</b> .....	<b>4</b>
<b>References</b> .....	<b>4</b>
<b>1 Overview</b> .....	<b>5</b>
<b>2 SDK Build</b> .....	<b>5</b>
<b>3 Application Programming Interface</b> .....	<b>6</b>
3.1 Operation APIs.....	6
3.2 Configuration APIs .....	7
<b>4 Example Code</b> .....	<b>9</b>
4.1 MQTT Publisher .....	9
4.2 MQTT Subscriber .....	10
4.3 Receiving/Processing Message (from MQTT Publisher).....	10
4.4 Periodic Message Publishing.....	11
4.5 Running Sub and Pub at the Same Time (with DPM) .....	11
4.6 MQTT Client Sample.....	12
<b>5 Test</b> .....	<b>13</b>
5.1 Test Environment .....	13
5.2 Setup.....	13
5.3 Publisher .....	14
5.3.1 Non-QoS Message .....	14
5.3.2 QoS Message .....	15
5.3.3 MQTT over TLS .....	17
5.3.4 Username and Password .....	18
5.4 Subscriber .....	19
5.4.1 Setup .....	19
5.4.2 MQTT over TLS.....	19
5.4.3 Username and Password .....	19
5.4.4 WILL.....	20
5.5 MQTT Pub/Sub Test with DPM and TLS.....	20
5.5.1 MQTT Reconnection Scheme .....	22
5.5.2 DPM Power Profile .....	22
5.6 Reset.....	23
<b>6 Certificate</b> .....	<b>24</b>
6.1 Certificate Commands.....	24
6.2 CA, Client Cert, and Client Key.....	25
<b>Revision History</b> .....	<b>29</b>

DA16200 MQTT Programmer Guide

**Figures**

Figure 1: MQTT Messaging Concept ..... 5  
 Figure 2: Publish Non-QoS Message ..... 14  
 Figure 3: Publish QoS 1 Message..... 15  
 Figure 4: Publish QoS 2 Message..... 16  
 Figure 5: Configure Parameters and Publish a Message ..... 16  
 Figure 6: Publish Secure Message ..... 17  
 Figure 7: User Login ..... 18  
 Figure 8: DPM Sleep after MQTT Connection ..... 21  
 Figure 9: MQTT UC Wakeup..... 21  
 Figure 10: MQTT Wakeup for Sending Message..... 22  
 Figure 11: MQTT Communication ..... 23

**Tables**

Table 1: MQTT API List ..... 6  
 Table 2: Configuration API ..... 7  
 Table 3: MQTT Messaging Configuration (String Type) ..... 7  
 Table 4: MQTT Messaging Configuration (Integer Type)..... 7

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## DA16200 MQTT Programmer Guide

### Terms and Definitions

MQTT	Message Queuing Telemetry Transport
DPM	Dynamic Power Management
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
API	Application Programming Interface
AP	Access Point
QoS	Quality of Service
TLS	Transport Layer Security

### References

- [1] DA16200, Datasheet, Dialog Semiconductor
- [2] DA16200, SDK Programmer Guide, Dialog Semiconductor

DA16200 MQTT Programmer Guide

## 1 Overview

MQTT (Message Queue Telemetry Transport) is an ISO standard (ISO/IEC PRF 20922) publish-subscribe-based messaging protocol. It works on top of the TCP/IP protocol. The publisher sends (PUBLISH) messages to the subscriber through the broker. The subscriber needs to keep the connection with the broker by TCP session while the publisher can disconnect the session with the broker after sending a message.

As shown in Figure 1, once the broker receives a message with a specific topic the message is sent to subscribers that already registered with the topic. A subscriber can register with more than one topic. There can be many or no subscribers which registered with a specific topic.

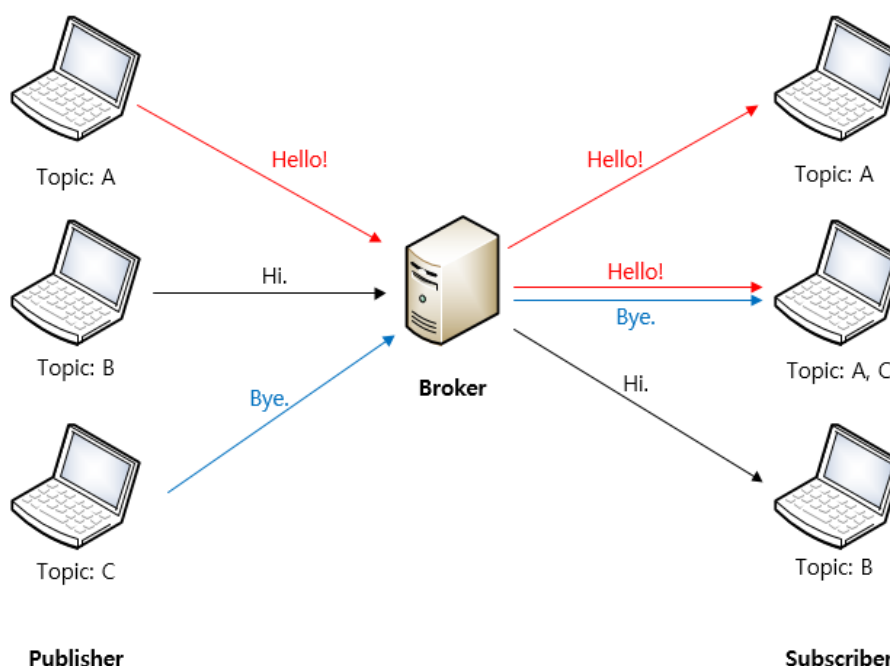


Figure 1: MQTT Messaging Concept

The exchange of MQTT messages supports QoS (Quality of Service). QoS has three levels (0, 1, and 2) and the process of each QoS level is as below.

The DA16200 supports both publisher and subscriber functions and allows simultaneous use. The subscriber function supports DPM mode. TLS is available for message encryption.

## 2 SDK Build

Some source files should be modified in the DA16200 SDK to use the MQTT function.

Enable the MQTT function as shown in the example below.

```
config_generic_sdk.h
...
#define SUPPORT_MQTT // Support MQTT
```

## DA16200 MQTT Programmer Guide

### 3 Application Programming Interface

#### 3.1 Operation APIs

The APIs listed in [Table 1](#) are used to create or terminate the MQTT thread, to check the status, and to publish a message. The configuration to execute MQTT protocols is explained in the next section.

**Table 1: MQTT API List**

<code>int mqtt_client_start(void)</code>		
Return	If succeeded, returns 0. If failed, returns an error code.	
Description	Create the MQTT client thread.	
<code>int mqtt_client_stop(void)</code>		
Return	If succeeded, returns 0. If there is no thread to terminate, returns -1.	
Description	Terminate the MQTT client thread.	
<code>int mqtt_client_check_conn(void)</code>		
Return	1 (true): Connected to a broker. 0 (false): Not connected.	
Description	Check whether the MQTT session is connected.	
<code>int mqtt_client_send_message(char *top, char *publish)</code>		
Return	0: Succeeded to publish. -1: Failed to publish because Publisher is not ready to send.	
Parameter	top	Topic (if NULL, the MQTT publisher sends a PUBLISH message with the topic stored in NVRAM.)
	publish	Message to be published.
Description	Publisher sends an MQTT message (PUBLISH).	
<code>int mqtt_client_send_message_with_qos(char *top, char *publish, timeout)</code>		
Return	0: Succeeded to publish. -1: Failed to publish because Publisher is not ready to send. -2: Failed to publish because the timeout expired.	
Parameter	top	Topic (if NULL, the MQTT module sends a PUBLISH message with the topic stored in NVRAM.)
	publish	Message to be published.
	timeout	Timeout to wait for a previous QoS message to process completely (unit: 10 ms).
Description	Publisher sends an MQTT message (PUBLISH) with a timeout check.	

## DA16200 MQTT Programmer Guide

### 3.2 Configuration APIs

With NVRAM items, the user can configure MQTT messaging. This allows configuring the publisher and the subscriber.

**Table 2: Configuration API**

<code>int mqtt_client_config_initialize(void)</code>	
Return	If succeeded, returns 0 (MOSQ_ERR_SUCCESS. If failed, returns an error code.
Description	Reset all MQTT Configurations.

**Table 3: MQTT Messaging Configuration (String Type)**

Name	Description	Example
DA16X_CONF_STR_MQTT_BROKER_IP	Broker IP address (or URI).	<code>dal6x_set_config_str(DA16X_CONF_STR_MQTT_BROKER_IP, "192.168.0.1");</code>
DA16X_CONF_STR_MQTT_SUB_TOPIC	Subscriber topic (previous topics will be removed).	<code>dal6x_set_config_str(DA16X_CONF_STR_MQTT_SUB_TOPIC, topic);</code>
DA16X_CONF_STR_MQTT_SUB_TOPIC_ADD	Subscriber topic to add (up to four).	<code>dal6x_set_config_str(DA16X_CONF_STR_MQTT_SUB_TOPIC_ADD, topic);</code>
DA16X_CONF_STR_MQTT_SUB_TOPIC_DEL	Subscriber topic to remove.	<code>dal6x_set_config_str(DA16X_CONF_STR_MQTT_SUB_TOPIC_DEL, topic);</code>
DA16X_CONF_STR_MQTT_PUB_TOPIC	Topic to publish.	<code>dal6x_set_config_str(DA16X_CONF_STR_MQTT_PUB_PUB_TOPIC, "pub topic");</code>
DA16X_CONF_STR_MQTT_USERNAME	Username to log in to a broker.	<code>dal6x_set_config_str(DA16X_CONF_STR_MQTT_USERNAME, "mqtt_id");</code>
DA16X_CONF_STR_MQTT_PASSWORD	Password to login to a broker.	<code>dal6x_set_config_str(DA16X_CONF_STR_MQTT_PASSWORD, "mqtt_password");</code>
DA16X_CONF_STR_MQTT_WILL_TOPIC	Will Topic.	<code>dal6x_set_config_str(DA16X_CONF_STR_MQTT_WILL_TOPIC, "will topic");</code>
DA16X_CONF_STR_MQTT_WILL_MSG	Will Message.	<code>dal6x_set_config_str(DA16X_CONF_STR_MQTT_WILL_MSG, "will msg");</code>
DA16X_CONF_STR_MQTT_SUB_CLIENT_ID	MQTT client ID.	<code>dal6x_set_config_str(DA16X_CONF_STR_MQTT_SUB_CLIENT_ID, "sub id");</code>

**Note 1** Up to four subscriber topics can be registered, and only one publisher topic can be registered.

**Table 4: MQTT Messaging Configuration (Integer Type)**

Name	Description	Example
DA16X_CONF_INT_MQTT_SUB	MQTT operation (0: stop, 1: start).	<code>dal6x_set_config_int(DA16X_CONF_INT_MQTT_SUB, 1);</code>
DA16X_CONF_INT_MQTT_AUTO	MQTT Auto-start at booting system (0: disable, 1: enable).	<code>dal6x_set_config_int(DA16X_CONF_INT_MQTT_AUTO, 1);</code>
DA16X_CONF_INT_MQTT_PORT	Broker port number.	<code>dal6x_set_config_int(DA16X_CONF_INT_MQTT_PORT, 8883);</code>
DA16X_CONF_INT_MQTT_QOS	QoS level (0~2).	<code>dal6x_set_config_int(DA16X_CONF_INT_MQTT_QOS, 2);</code>

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**DA16200 MQTT Programmer Guide**

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<b>Name</b>	<b>Description</b>	<b>Example</b>
DA16X_CONF_INT_MQTT_TLS	TLS (0: disable, 1: enable).	<code>da16x_set_config_int(DA16X_CONF_INT_MQTT_TLS, 1);</code>
DA16X_CONF_INT_MQTT_WILL_QOS	QoS level of will messages (0~2).	<code>da16x_set_config_int(DA16X_CONF_INT_MQTT_WILL_QOS, 1);</code>
DA16X_CONF_INT_MQTT_PING_PERIOD	MQTT ping period (secs).	<code>da16x_set_config_int(DA16X_CONF_INT_MQTT_PING_PERIOD, 86400);</code>



## DA16200 MQTT Programmer Guide

### 4 Example Code

DA16200 MQTT publisher and subscriber are configured by NVRAM items. Once all configurations are done, you just need to run the subscriber thread or publish an MQTT message.

#### 4.1 MQTT Publisher

Set the configurations for the MQTT broker, publisher topic, and so on (once after boot, or when you want to change). Call `mqtt_client_start()` and `mqtt_client_send_message()` with a message, then DA16200 will temporarily connect to the broker and publish the message.

```
#include "mqtt_client.h"
#include "common_config.h"

int mqtt_pub_example(void)
{
    int status;
    char send_msg[16] = {0, }

    strcpy(send_msg, "Hello broker.");

    da16x_set_nvcache_str(DA16X_CONF_STR_MQTT_BROKER_IP, "172.16.0.1");
    da16x_set_nvcache_int(DA16X_CONF_INT_MQTT_PORT, 1884);
    da16x_set_nvcache_str(DA16X_CONF_STR_MQTT_PUB_TOPIC, "da16k_pub");
    da16x_set_nvcache_str(DA16X_CONF_STR_MQTT_USERNAME, "username");
    da16x_set_nvcache_str(DA16X_CONF_STR_MQTT_PASSWORD, "password");
    da16x_set_nvcache_int(DA16X_CONF_INT_MQTT_QOS, 0);
    da16x_set_nvcache_int(DA16X_CONF_INT_MQTT_TLS, 0);

    da16x_nvcache2flash();

    status = mqtt_client_start();
    if (status)
    {
        PRINTF("Failed to initialize MQTT Client.");
        return status;
    }

    tx_thread_sleep(300); // sleep 3 sec.(=300 ticks) /* for SDK V2.x.x.x */
    // vTaskDelay(300); /* for SDK V3.x.x.x */

mqtt_pub_send:
    status = mqtt_client_check_conn();
    if (!status)
    {
        mqtt_client_send_message(NULL, send_msg);
    }
    else
    {
        tx_thread_sleep(100); // sleep 1 sec. /* for SDK V2.x.x.x */
        // vTaskDelay(100); /* for SDK V3.x.x.x */

        goto mqtt_pub_send;
    }

    return status;
}
```

## DA16200 MQTT Programmer Guide

### 4.2 MQTT Subscriber

Set the configurations for the MQTT broker, subscriber topic, and so on (once before running the subscriber thread). Call `mqtt_client_start()` and then the subscriber thread will start.

```
#include "mqtt_client.h"
#include "common_config.h"

int mqtt_sub_example(void)
{
    int status;

    da16x_set_nvcache_str(DA16X_CONF_STR_MQTT_BROKER_IP, "172.16.0.1");
    da16x_set_nvcache_int(DA16X_CONF_INT_MQTT_PORT, 1884);
    da16x_set_nvcache_str(DA16X_CONF_STR_MQTT_SUB_TOPIC, "da16k_sub");
    da16x_set_nvcache_str(DA16X_CONF_STR_MQTT_USERNAME, "username");
    da16x_set_nvcache_str(DA16X_CONF_STR_MQTT_PASSWORD, "password");
    da16x_set_nvcache_int(DA16X_CONF_INT_MQTT_QOS, 0);
    da16x_set_nvcache_int(DA16X_CONF_INT_MQTT_TLS, 0);

    da16x_nvcache2flash();

    status = mqtt_client_start();

    return status;
}
```

### 4.3 Receiving/Processing Message (from MQTT Publisher)

When an MQTT message is received, it is received via a callback, which a user programmer needs to register. To be able to add a callback, Section 4.2 should be done first (file `mqtt_client.h` should be included).

```
mqtt_client_set_msg_cb(mqtt_msg_cb);
```

#### NOTE

The user thread that registers a message callback should have the same or higher priority than the "mqtt\_client" thread (the priority of the mqtt\_client thread is currently `USER_PRI_APP(1)`) for mqtt\_client to be able to register the user callback before MQTT initialization.

The following example code shows a callback sample implementation. In this implementation, when a message is received, and if the payload is "1", a certain message is printed.

```
static void mqtt_msg_cb (const char *buf, int len, const char *topic)
{
    if (strncmp(message->payload, "1", 1) == 0)
    {
        char msg[64] = {0, };

        sprintf(msg, "DA16X status: Not bad (%d)", ++mqtt_sample_msg_id);
        mqtt_client_send_message(NULL, msg);
    }
}
```

## DA16200 MQTT Programmer Guide

### 4.4 Periodic Message Publishing

When an MQTT Publisher session is connected, you can register a periodic message function. To be able to send it, you should call the callback API as below.

With MQTT Publisher, you can post a periodic message. Section 4.1 should be done first.

```
mqtt_client_set_pub_cb(mqtt_pub_cb);
```

```
#define MQTT_PUB_MSG_PERIODIC 30 // secs
static void mqtt_pub_cb(void)
{
    if (!dpm_mode_is_wakeup())
    {
        dpm_timer_create(SAMPLE_MQTT_CLIENT, "timer1",
                        mqtt_pub_send_periodic,
                        MQTT_PUB_MSG_PERIODIC,
                        MQTT_PUB_MSG_PERIODIC);
    }
}
```

For a duplicate RTC timer registration, it is only registered on Power-On-Boot. That means, when the RTC timer is expired, a message is printed on the console.

```
static void mqtt_pub_send_periodic(char *timer_name)
{
    char msg[64] = {0, };

    strcpy(msg, "DA16K Periodic Message");
    mqtt_client_send_message(NULL, msg);
}
```

### 4.5 Running Sub and Pub at the Same Time (with DPM)

```
void cmd_mqtt_sample(int argc, char *argv[])
{
    /* Wi-Fi Connection Setting */
    dal6x_set_nvcache_int(DA16X_CONF_INT_MODE, 0);
    dal6x_set_nvcache_str(DA16X_CONF_STR_SSID_0, "TEST_AP");
    dal6x_set_nvcache_int(DA16X_CONF_INT_AUTH_MODE_0, CC_VAL_AUTH_WPA2);
    dal6x_set_nvcache_int(DA16X_CONF_INT_ENCRYPTION_0, CC_VAL_ENC_CCMP);
    dal6x_set_nvcache_str(DA16X_CONF_STR_PSK_0, "12345678");

    /* MQTT Setting */
    dal6x_set_nvcache_int(DA16X_CONF_INT_MQTT_AUTO, 1);
    dal6x_set_nvcache_str(DA16X_CONF_STR_MQTT_BROKER_IP, "172.16.0.1");
    dal6x_set_nvcache_int(DA16X_CONF_INT_MQTT_PORT, 8883);
    dal6x_set_nvcache_int(DA16X_CONF_INT_MQTT_QOS, 0);
    dal6x_set_nvcache_int(DA16X_CONF_INT_MQTT_TLS, 1);
    dal6x_set_nvcache_str(DA16X_CONF_STR_MQTT_SUB_TOPIC, "da16k");
    dal6x_set_nvcache_str(DA16X_CONF_STR_MQTT_PUB_TOPIC, "da16k_sub");
    dal6x_set_nvcache_int(DA16X_CONF_INT_MQTT_PING_PERIOD, 60);

    /* DPM after Rebooting */
    dal6x_set_nvcache_int(DA16X_CONF_INT_DPM, 1);

    /* Enabled SNTP for TLS */
}
```

## DA16200 MQTT Programmer Guide

```
da16x_set_nvcache_int(DA16X_CONF_INT_SNTP_CLIENT, 1);

da16x_nvcache2flash();

/* Input Certificate & Private Key */
cert_flash_write(SFLASH_ROOT_CA_ADDR1, (char *)cert_buffer0,
                 strlen(cert_buffer0));
cert_flash_write(SFLASH_CERTIFICATE_ADDR1, (char *)cert_buffer1,
                 strlen(cert_buffer1));
cert_flash_write(SFLASH_PRIVATE_KEY_ADDR1, (char *)cert_buffer2,
                 strlen(cert_buffer2));
reboot_func(SYS_REBOOT, DISCONNECT_SEND);
}
```

### 4.6 MQTT Client Sample

MQTT client sample is found in [SDK V2.x.x.x: ~/sample/Network/MQTT\_Client/mqtt\_user\_sample.c] or [SDK V3.x.x.x: ~/samples/Network/MQTT\_Client\_Sample/src/mqtt\_user\_sample.c].

This simple application demonstrates receiving and sending an MQTT message. For building, running, and sample guide, see ~/doc/html/mqtt\_client\_sample.html (SDK V2.x.x.x).

## DA16200 MQTT Programmer Guide

### 5 Test

This section explains how to test the MQTT function on the DA16200 debug console window.

#### 5.1 Test Environment

For this test the mosquitto MQTT broker is used, which you can download from the following URL:

<https://mosquitto.org/download/>

If you feel that the broker installation is difficult, Dialog Semiconductor can provide it so that you can extract and run it on your Windows PC.

#### 5.2 Setup

Open a command window and go to the mosquitto folder.

1. Run a broker.

```
mosquitto -v -p <Port Number>
```

```
C:\#mosquitto>mosquitto -v -p 1884
1582173416: mosquitto version 1.4.14 (build date 11/07/2017 0:03:18.53) starting
1582173416: Using default config.
1582173416: Opening ipv6 listen socket on port 1884.
1582173416: Opening ipv4 listen socket on port 1884.
```

2. Open a new command window and run a subscriber.

```
mosquitto_sub -h <Broker IP> -p <Port Number> -t <Topic>
```

```
C:\#mosquitto>mosquitto_sub -h 172.16.30.163 -p 1884 -t da16k
```

The following message is shown in the broker window.

```
C:\#mosquitto>mosquitto -v -p 1884
1582173276: mosquitto version 1.4.14 (build date 11/07/2017 0:03:18.53) starting
1582173276: Using default config.
1582173276: Opening ipv6 listen socket on port 1884.
1582173276: Opening ipv4 listen socket on port 1884.
1582173309: New connection from 172.16.30.163 on port 1884.
1582173309: New client connected from 172.16.30.163 as mosqsub|13800-KR-ENG-LT (c1, k60)
1582173309: Sending CONNACK to mosqsub|13800-KR-ENG-LT (0, 0)
1582173309: Received SUBSCRIBE from mosqsub|13800-KR-ENG-LT
1582173309: da16k (QoS 0)
1582173309: mosqsub|13800-KR-ENG-LT 0 da16k
1582173309: Sending SUBACK to mosqsub|13800-KR-ENG-LT
```

3. Open a new command window and publish a message.

```
mosquitto_pub -h <Broker IP> -p <Port Number> -t <Topic> -m "<Message>"
```

```
C:\#mosquitto>mosquitto_pub -h 172.16.30.163 -p 1884 -t da16k -m "Hello World!"
```

## DA16200 MQTT Programmer Guide

The following message is shown in the broker window.

```
582173567: New connection from 172.16.30.163 on port 1884.
582173567: New client connected from 172.16.30.163 as mosqpub|3508-KR-ENG-LT- (c1, k60).
582173567: Sending CONNACK to mosqpub|3508-KR-ENG-LT- (0, 0)
582173567: Received PUBLISH from mosqpub|3508-KR-ENG-LT- (d0, q0, r0, m0, 'da16k', ... (12 bytes))
582173567: Sending PUBLISH to mosqsub|17076-KR-ENG-LT (d0, q0, r0, m0, 'da16k', ... (12 bytes))
582173567: Received DISCONNECT from mosqpub|3508-KR-ENG-LT-
582173567: Client mosqpub|3508-KR-ENG-LT- disconnected.
```

The subscriber receives the message.

```
C:\#mosquitto>mosquitto_sub -h 172.16.30.163 -p 1884 -t da16k
Hello World!
```

### 5.3 Publisher

#### 5.3.1 Non-QoS Message

This section gives an example of publishing a non-QoS message.

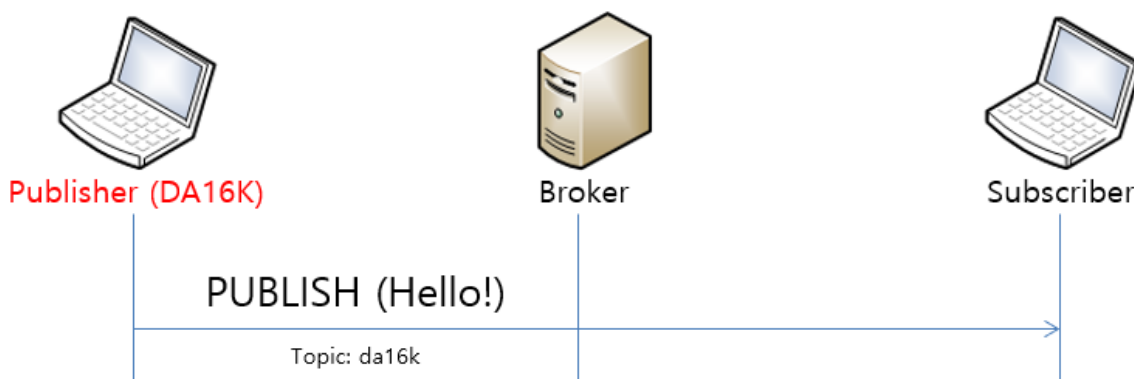


Figure 2: Publish Non-QoS Message

1. After the DA16200 EVB is connected to an AP, configure the parameters and publish a message.

```
[/DA16200]# net
[/DA16200/NET]# mqtt_config broker <Broker IP>
[/DA16200/NET]# mqtt_config port <Port Number>
[/DA16200/NET]# mqtt_config pub_topic <Topic>
[/DA16200/NET]# mqtt_client start
>>> MQTT Client connection OK (da16x_FFFE)

[/DA16200/NET]# mqtt_client -m <Message>
...
[/DA16200/NET]# mqtt_client stop
```

Optionally, “client\_id” can also be set with the following command:

```
[/DA16200/NET]# mqtt_config client_id <client_id_string>
```

For example, `mqtt_config client_id abcd1111`

client\_id should be unique per each device. By default, client\_id is generated internally like “da16x\_<the last 2 bytes of mac address>”. For example, da16x\_FCFA.

DA16200 MQTT Programmer Guide

2. When message transmission -m "Hello!" is successful, you can see the following messages:  
Hello! (Send, Len: 6, Topic: da16k, Message ID: 1) The following syntax allows to send a message with a new topic:

```
[/DA16200/NET] mqtt_client -m <Message> <NewTopic>
```

If the previous parameters for broker, port, and topics are not changed, then you do not need to set the parameters for the publication of every message.

\* The max length of the console command is 158. To send a longer PUBLISH, write the following command:

```
[/DA16200/NET] mqtt_client -l
Typing data: (MQTT Publisher message)
Cancel - CTRL+D, End of Input - CTRL+C or CTRL+Z
12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012
3456789012345678901234567890123456789012345678901234567890123456789012345678901234
5678901234567890123456789012345678901234567890123456789012345678901234567890123456
7890 ...
```

Use the keyboard combinations Ctrl+C or Ctrl+Z to send the message.

5.3.2 QoS Message

This section gives an example of publishing a QoS message.

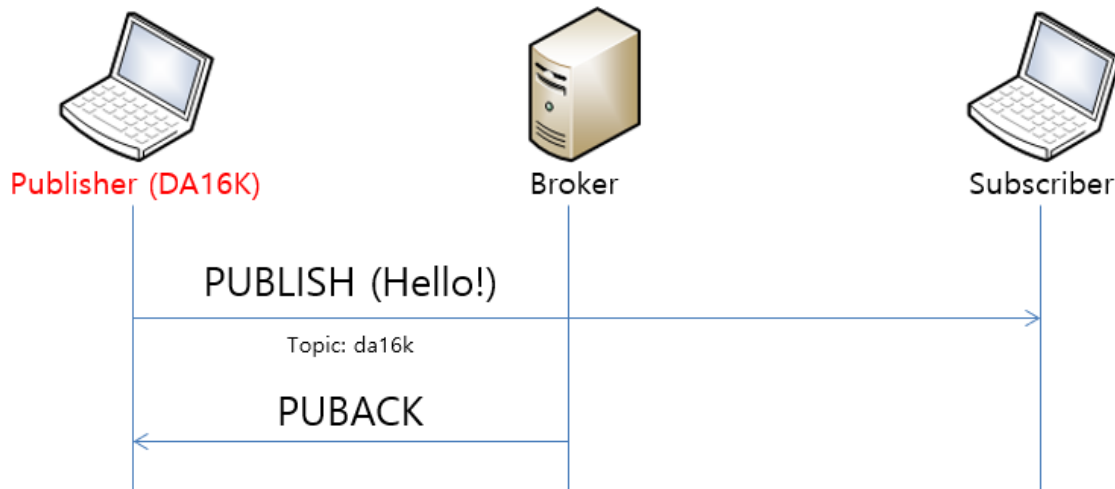


Figure 3: Publish QoS 1 Message

DA16200 MQTT Programmer Guide

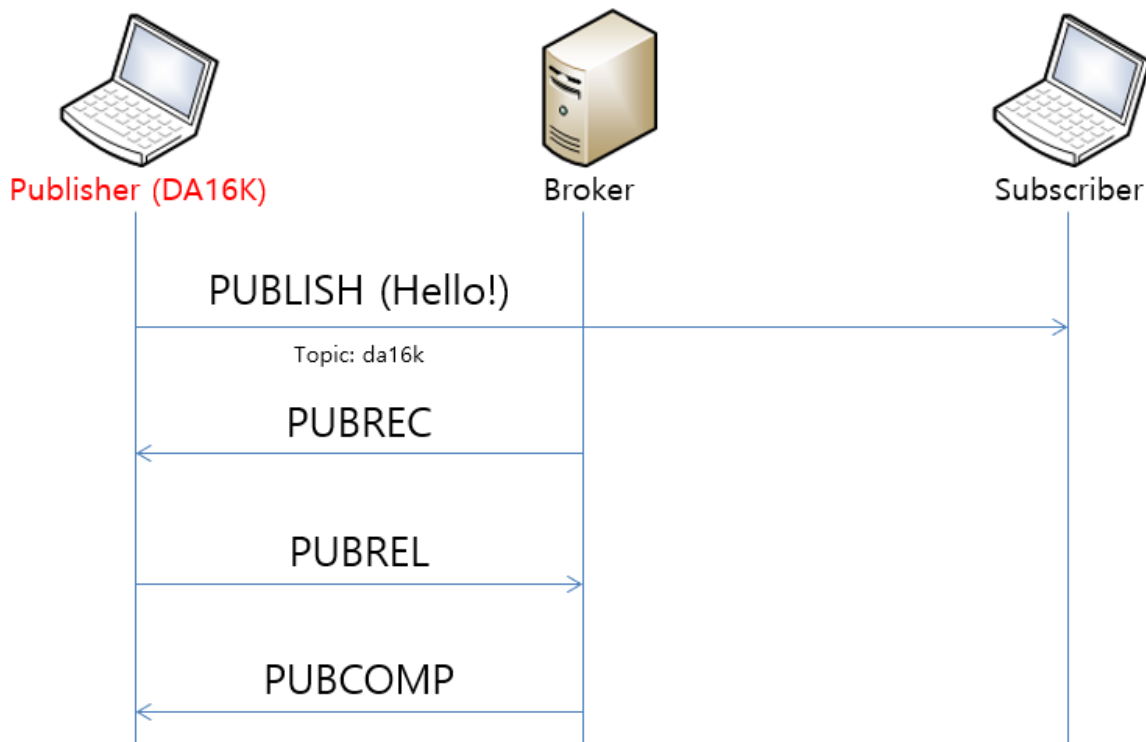


Figure 4: Publish QoS 2 Message

1. Configure the parameters and publish a message.

```

[/DA16200/NET]# mqtt_config broker <Broker IP>
[/DA16200/NET]# mqtt_config port <Port Number>
[/DA16200/NET]# mqtt_config pub_topic <Topic>
[/DA16200/NET]# mqtt_config qos <QoS Level>
[/DA16200/NET]# mqtt_client start
>>> MQTT Client connection OK (da16x_FFFE)

[/DA16200/NET]# mqtt_client -m <Message>

1582175804: Received PUBLISH from PUB-da16x_FD26 (d0, q1, r0, m1, 'da16k', ... (6 bytes))
1582175804: Sending PUBACK to PUB-da16x_FD26 (Mid: 1)

1582175859: Received PUBLISH from PUB-da16x_FD26 (d0, q2, r0, m1, 'da16k', ... (6 bytes))
1582175859: Sending PUBREC to PUB-da16x_FD26 (Mid: 1)
1582175859: Received PUBREL from PUB-da16x_FD26 (Mid: 1)
1582175859: Sending PUBCOMP to PUB-da16x_FD26 (Mid: 1)
    
```

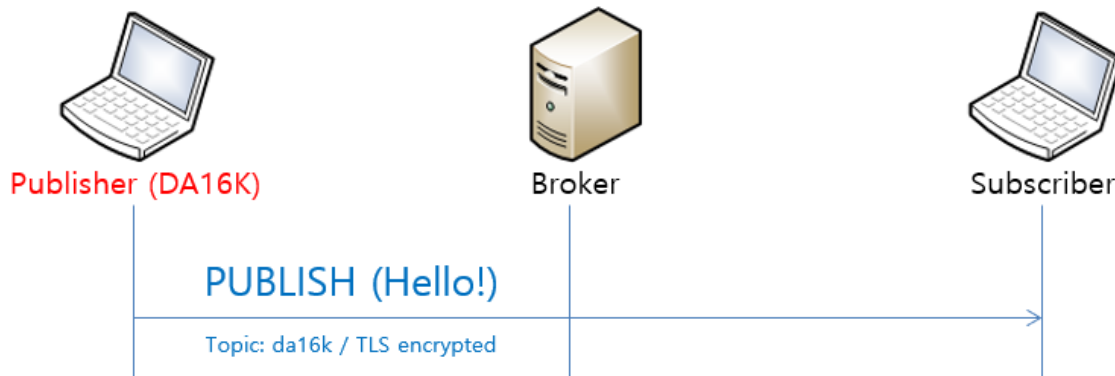
Figure 5: Configure Parameters and Publish a Message



## DA16200 MQTT Programmer Guide

### 5.3.3 MQTT over TLS

The DA16200 SDK provides a TLS encrypted session for secure MQTT messages.



**Figure 6: Publish Secure Message**

**NOTE**

You need to store certificates in the DA16200 EVK to use TLS encryption. This procedure is explained in Section 6.

1. Run a broker with a secure port.

```
mosquitto -c mosquitto.conf -p <Port Number> -v
```

```
C:\#mosquitto>mosquitto -c mosquitto.conf -p 8883 -v
1582174980: mosquitto version 1.4.14 (build date 11/07/2017 0:03:18.53) starting
1582174980: Config loaded from mosquitto.conf.
1582174980: Opening ipv6 listen socket on port 8883.
1582174980: Opening ipv4 listen socket on port 8883.
```

2. Run a subscriber.

```
mosquitto_sub -h <Broker IP> -p <Port> --cafile <CA Certificate> --cert <Client Certificate> --key <Client Private Key> --tls-version <TLS Protocol Version> --insecure -t <Topic>
```

```
C:\#mosquitto>mosquitto_sub -h 172.16.30.163 -p 8883 --cafile cas.pem --cert wifiuser.pem --key wifiuser.key --tls-version tlsv1 --insecure -t da16k
```

3. Set the current time in the DA16200 EVB to check if the certificate is valid.  
(If you want to use SNTP for time sync, input the command “net.sntp enable” to get the current time.)

```
[/DA16200]# time set <yyyy-mm-dd> <hh:mm:ss>
```

4. Store three Certificates (see Section 6.1) in the DUT, and then follow the steps below.

```
[/DA16200/NET]# mqtt_config broker <Broker IP>
[/DA16200/NET]# mqtt_config port <Port Number>
[/DA16200/NET]# mqtt_config pub_topic <Topic>
[/DA16200/NET]# mqtt_config tls 1
[/DA16200/NET]# mqtt_client start
>>> MQTT Client connection OK (da16x_FFFE)

[/DA16200/NET]# mqtt_client -m <Message>
```

## DA16200 MQTT Programmer Guide

### 5.3.4 Username and Password

1. Set up a username and password to authenticate users.

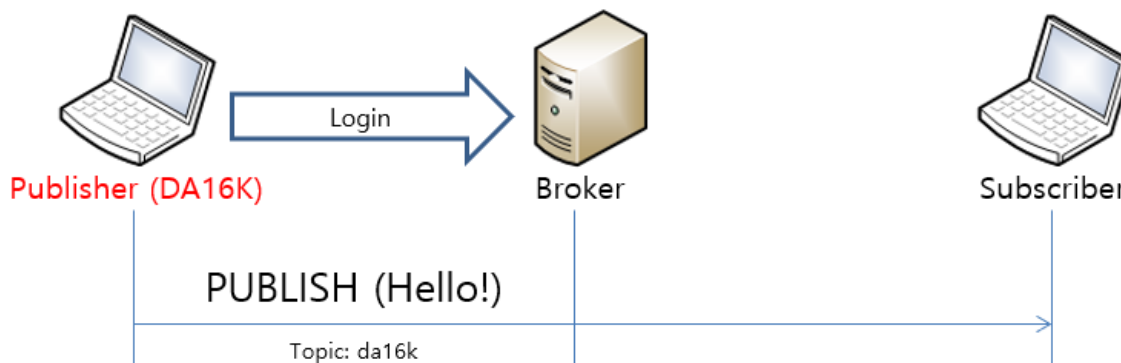


Figure 7: User Login

2. Run a broker with a secure port. You need to prepare the configuration file.

```
mosquitto -c <Config File> -p <Port> -v
```

```
C:\#mosquitto>mosquitto -c mosq_idpw.conf -p 1900 -v
1582176530: mosquitto version 1.4.14 (build date 11/07/2017 0:03:18.53) starting
1582176530: Config loaded from mosq_idpw.conf.
1582176530: Opening ipv6 listen socket on port 1900.
1582176530: Opening ipv4 listen socket on port 1900.
```

In the mosquitto package provided by Dialog Semiconductor, file `mosq_idpw.conf` is used for the `<Config File>` parameter, and user accounts are registered in file `p1.txt`.

3. You can add a new account in this file with the following command:

```
mosquitto_passwd.exe -b p1.txt <username> <password>
```

4. At the mosquitto command prompt, please run the `mosquitto_sub` command to log in successfully to the broker.

```
mosquitto sub -h <broker ip> -p <port> -t <topic> -u <id> -P <pass>
```

5. On `mqtt_client` (DUT), set the username and password, and start `mqtt_client`.

```
[/DA16200/NET]# mqtt_config broker <Broker IP>
[/DA16200/NET]# mqtt_config port <Port Number>
[/DA16200/NET]# mqtt_config pub_topic <Topic>
[/DA16200/NET]# mqtt_config tls 0
[/DA16200/NET]# mqtt_config username <Username>
[/DA16200/NET]# mqtt_config password <Password>
[/DA16200/NET]# mqtt_client start
>>> MQTT Client connection OK (da16x_FFFE)

[/DA16200/NET]# mqtt_client -m <Message>
```

#### NOTE

- The max length of the console command is 158 so to type in a password exceeding the limit of the console, use the command "mqtt\_config long\_password"
- The max length of the buffer is currently 160 for a password, 64 for a username. If you want to change max length, modify `MQTT_USERNAME_MAX_LEN` or `MQTT_PASSWORD_MAX_LEN`, if required

## DA16200 MQTT Programmer Guide

### 5.4 Subscriber

#### 5.4.1 Setup

1. Configure the parameters and start the subscriber.

```
[/DA16200/NET]# mqtt_config broker <Broker IP>
[/DA16200/NET]# mqtt_config port <Port Number>
[/DA16200/NET]# mqtt_config sub_topic 1 <Topic>
[/DA16200/NET]# mqtt_client start
>>> MQTT Client connection OK (da16x_FFFE)
...
[/DA16200/NET]# mqtt_client stop
```

2. You can register multiple topics. You should add the parameter for the number of topics in the command (up to four).

```
[/DA16200/NET]# mqtt_client stop
[/DA16200/NET]# mqtt_config sub_topic <Topic count> <Topic#1> <Topic#2> ...
[/DA16200/NET]# mqtt_client start
>>> MQTT Client connection OK (da16x_FFFE)
...
[/DA16200/NET]# mqtt_config sub_topic_add <New topic>
[/DA16200/NET]# mqtt_config sub_topic_del <Topic to remove>
```

#### 5.4.2 MQTT over TLS

You need to set the current time in the DA16200 EVB to check if the certificate is valid.

(If SNTP is auto started during boot, you do not need to do this step.)

```
[/DA16200]# time set <yyyy-mm-dd> <hh:mm:ss>
```

1. Run the broker as below.

```
mosquitto -c mosquitto.conf -p <Port Number> -v
```

2. Add three Certificates (see Section 6.1) for the DUT, and then do the steps below.

```
[/DA16200/NET]# mqtt_config broker <Broker IP>
[/DA16200/NET]# mqtt_config port <Port Number>
[/DA16200/NET]# mqtt_config sub_topic 1 <Topic>
[/DA16200/NET]# mqtt_config tls 1
[/DA16200/NET]# mqtt_client start
>>> MQTT Client connection OK (da16x_FFFE)
```

3. Run a publisher on your PC.

```
mosquitto_pub -h <Broker IP> -p <Port> --cafile <CA Certificate> --cert <Client Certificate> --key <Client Private Key> --tls-version <TLS Protocol Version> -t <Topic> --insecure -m <message>
```

Example: mosquitto\_pub -h 192.168.0.101 -p 1884 --cafile cas.pem --cert wifiuser.pem --key wifiuser.key --tls-version tlsv1 -t da16k --insecure -m "hello"

#### 5.4.3 Username and Password

1. DUT: Set username and password.

```
[/DA16200/NET]# mqtt_config broker <Broker IP>
[/DA16200/NET]# mqtt_config port <Port Number>
[/DA16200/NET]# mqtt_config sub_topic 1 <Topic>
[/DA16200/NET]# mqtt_config tls 0
[/DA16200/NET]# mqtt_config username <Username>
```

## DA16200 MQTT Programmer Guide

```
[/DA16200/NET]# mqtt_config password <Password>
[/DA16200/NET]# mqtt_client start
>>> MQTT Client connection OK (da16x_FFFE)
```

- In the mosquitto package provided by Dialog Semiconductor, file `mosq_idpw.conf` is used for the <Config File> parameter and user accounts are registered in file `p1.txt`. You can add a new account in this file with the following command.

```
mosquitto_pub -h [Broker IP] -p [port] -t [topic] -m <message> -u [id] -P
[password]
```

Example:

```
mosquitto_pub -h 192.168.0.101 -p 1884 -t da16k -u mike -P 1234 -m hello
```

### 5.4.4 WILL

- Sub#1 (DUT): Set the will message.

```
[/DA16200/NET]# mqtt_config broker <Broker IP>
[/DA16200/NET]# mqtt_config port <Port Number>
[/DA16200/NET]# mqtt_config sub_topic 1 <Topic>
[/DA16200/NET]# mqtt_config will_topic <Topic>
[/DA16200/NET]# mqtt_config will_message <Message>
[/DA16200/NET]# mqtt_config will_qos <QoS Level>
[/DA16200/NET]# mqtt_client start
>>> MQTT Client connection OK (da16x_FFFE)
```

- Broker: Write the following command.

```
>mosquitto -v -p 1884
```

- Sub#2 (PC): Write the following command.

```
>mosquitto_sub -h 192.168.0.101 -t da16k -p 1884 -q 0
```

- Sub#1 (DUT): Try an unexpected disconnection.

```
[/DA16200/NET]# reset

>>> Network Interface (wlan0): DOWN
[mqtt_subscriber_main] Request mqtt_restart
[wpa_supplicant_event_disassoc] CTRL-EVENT-DISCONNECTED bssid=ec:08:6b:d6:53:62
reason=3 locally_generated=1

DA16200 ROM-Boot [ffffc000]
[MROM]
```

- Sub#2 (PC): Wait until the following will message is printed.

```
>mosquitto_sub -h 192.168.0.101 -t da16k -p 1884 -q 2
imwill
```

### 5.5 MQTT Pub/Sub Test with DPM and TLS

In this test, the Pub and Sub are run with the DPM mode enabled. In addition, an MQTT sample implementation (Section 4.3 and Section 4.4) is also enabled where the message callback and the Periodic Pub message posting are implemented.

- Broker: Run with TLS enabled.

```
>mosquitto -c mosquitto.conf -p 8883 -v
```

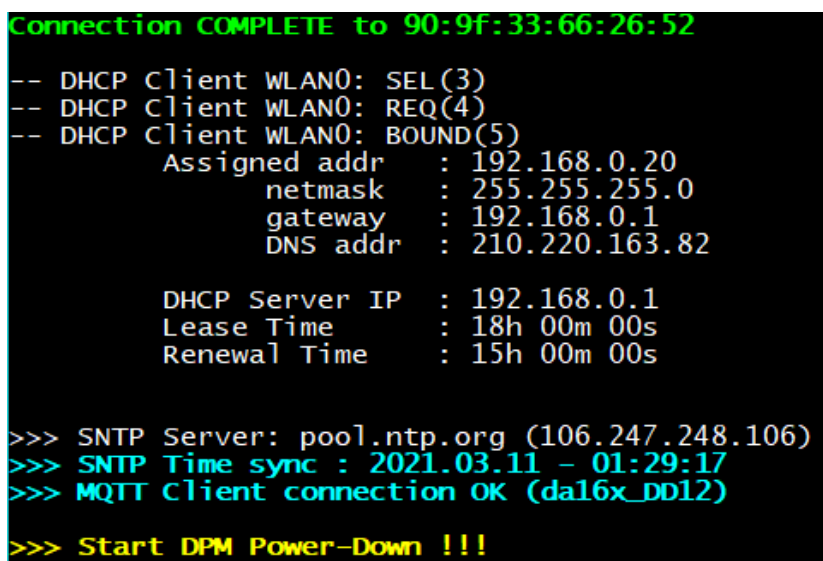
- Sub#2 (PC): Write the following command.

```
>mosquitto_sub -h 192.168.0.101 -p 8883 --cafile cas.pem --cert wifiuser.pem --key
wifiuser.key --tls-version tlsv1 -t da16k --insecure
```

## DA16200 MQTT Programmer Guide

### 3. Sub-Pub#1 (DUT): Write the following command.

```
[/DA16200/NET]# mqtt_config auto 1
[/DA16200/NET]# mqtt_config broker <Broker IP>
[/DA16200/NET]# mqtt_config port <Port Number>
[/DA16200/NET]# mqtt_config sub_topic 1 <Topic>
[/DA16200/NET]# mqtt_config pub_topic <Topic>
[/DA16200/NET]# mqtt_config tls 1
[/DA16200/NET]# sntp enable
[/DA16200/NET]# nvram.setenv dpm_mode 1
[/DA16200/NET]# reboot
```



```
Connection COMPLETE to 90:9f:33:66:26:52
-- DHCP Client WLAN0: SEL(3)
-- DHCP Client WLAN0: REQ(4)
-- DHCP Client WLAN0: BOUND(5)
   Assigned addr   : 192.168.0.20
   netmask         : 255.255.255.0
   gateway         : 192.168.0.1
   DNS addr        : 210.220.163.82

   DHCP Server IP  : 192.168.0.1
   Lease Time      : 18h 00m 00s
   Renewal Time    : 15h 00m 00s

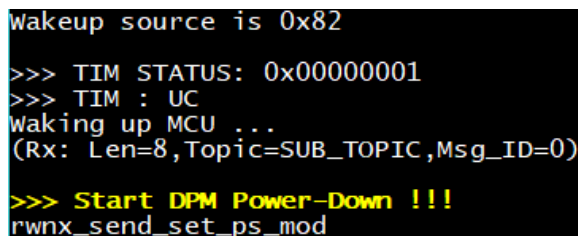
>>> SNTP Server: pool.ntp.org (106.247.248.106)
>>> SNTP Time sync : 2021.03.11 - 01:29:17
>>> MQTT Client connection OK (da16x_DD12)
>>> Start DPM Power-Down !!!
```

Figure 8: DPM Sleep after MQTT Connection

#Pub (PC): You can try to send the Pub message as below.

```
>mosquitto_pub -h 192.168.0.101 -p 1884 --cafile cas.pem --cert wifiuser.pem --key
wifiuser.key --tls-version tlsv1 -t da16k --insecure -m "Hello World!!"
```

When the message is received, DA16200 wakes up from DPM Sleep and prints the message.



```
wakeup source is 0x82
>>> TIM STATUS: 0x00000001
>>> TIM : UC
Waking up MCU ...
(Rx: Len=8,Topic=SUB_TOPIC,Msg_ID=0)
>>> Start DPM Power-Down !!!
rwnx_send_set_ps_mod
```

Figure 9: MQTT UC Wakeup

If the code examples in Sections 4.3 to 4.5 are applied, the MQTT publisher starts to post a periodic message every 30 seconds and the MQTT subscriber processes the received PUBLISH messages.

## DA16200 MQTT Programmer Guide

```
wakeup source is 0x82

(5)rtc_timeout
>>> TIM STATUS: 0x00000010
>>> TIM : FAST
(Tx: Len=26,Topic=PUB_TOPIC,Msg_ID=6)
<< Mqtt Pub EnQ : SUCCESS >>
[PUBREC] (Rx: Msg_ID=6)
[PUBREL] (Tx: Msg_ID=6)
[PUBCOMP] (Rx, Msg_ID=6)

>>> Start DPM Power-Down !!!
```

Figure 10: MQTT Wakeup for Sending Message

### 5.5.1 MQTT Reconnection Scheme

When the broker is disconnected, MQTT Client tries to reconnect to the broker based on the following scheme.

#### Non-DPM mode

1. MQTT Client tries reconnection six times (MQTT\_CONN\_MAX\_RETRY) and is terminated after the max number of trials is reached.

#### DPM mode

1. After disconnection from the broker is recognized, the system wakes up from the DPM Sleep, and MQTT Client tries reconnection three times (MQTT\_RESTART\_MAX\_RETRY) and the system enters DPM Sleep when the trials fail.
2. In five seconds, the system wakes up and MQTT Client tries reconnection with the broker. If it fails in connecting to the broker, the system enters the DPM Sleep.
3. “Step 2” is repeated six times (MQTT\_CONN\_MAX\_RETRY) and MQTT Client is terminated after the max number of trials (MQTT\_CONN\_MAX\_RETRY) is reached. The system then enters DPM Sleep.
4. In case other DPM wakeup (User Wakeup, user RTC Wakeup, UC, and so forth) happens after “Step 3”, “Step 2” is repeated six times.

### 5.5.2 DPM Power Profile

With Keysight, a current consumption measuring tester, you can check how DPM works in MQTT communication. DPM allows the system to stay in the Sleep mode most of the time and only wake up (and stay active for only a small amount of time to get the job done) when needed.

In the Keysight snapshot below, DA16200 was in the Sleep mode until it woke up to post a periodic status message to the broker. Once DA16200 received the response, it enters and stays in Sleep mode until the next Status Message Tx time (the interval depends on application).

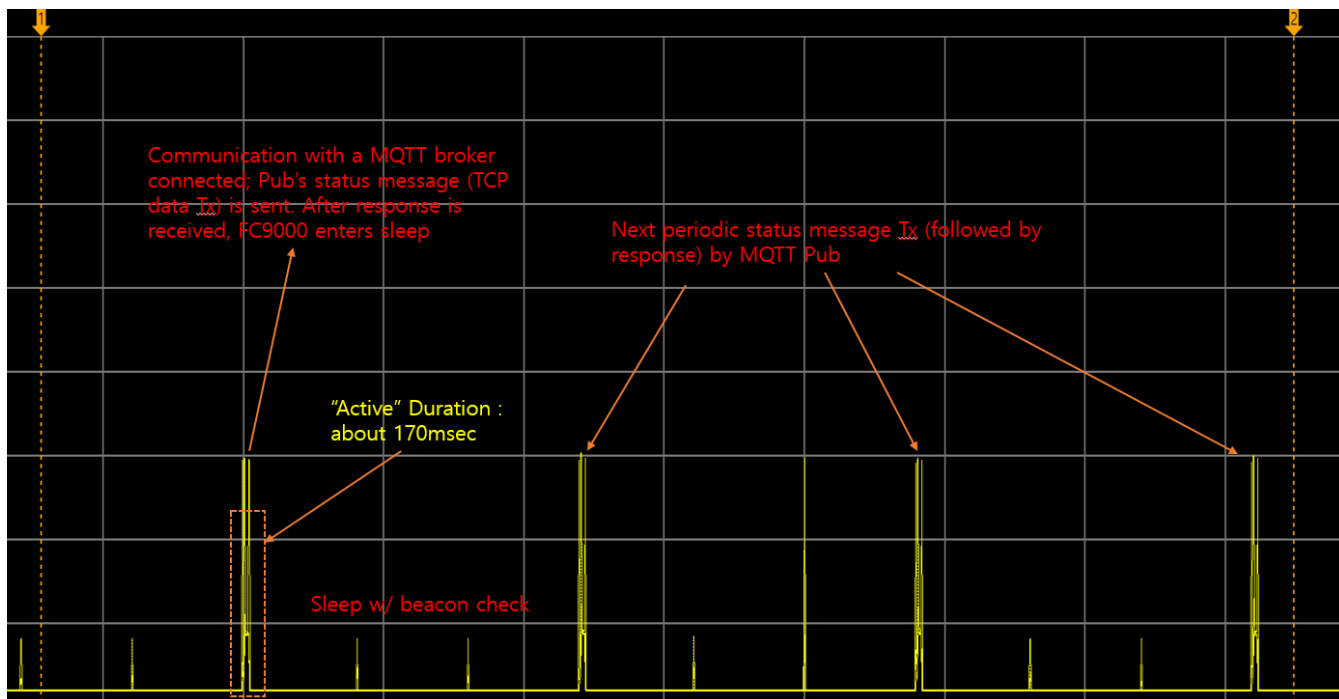


Figure 11: MQTT Communication

## 5.6 Reset

The following command clears all MQTT configurations:

```
[/DA16200/NET]# mqtt_config reset
```

## DA16200 MQTT Programmer Guide

### 6 Certificate

DA16200 provides methods to store certificates in the serial flash with the use of console commands.

#### 6.1 Certificate Commands

1. Store a CA certificate.

```
[/DA16200/NET]# net
[/DA16200/NET]# cert 0
Typing data: (certificate value)
Cancel - CTRL+D, End of Input - CTRL+C or CTRL+Z
// Copy & paste certificate data in the terminal window and press "CTRL+C" or "CTRL+Z"
(see Section 6.2)
```

2. Store a client certificate.

```
[/DA16200/NET]# cert 1
Typing data: (certificate value)
Cancel - CTRL+D, End of Input - CTRL+C or CTRL+Z
// Copy & paste certificate data in the terminal window and press "CTRL+C" or "CTRL+Z"
(see Section 6.2)
```

3. Store a client key.

```
[/DA16200/NET]# cert 2
Typing data: (certificate value)
Cancel - CTRL+D, End of Input - CTRL+C or CTRL+Z
// Copy & paste certificate data in the terminal window and press "CTRL+C" or "CTRL+Z"
(see Section 6.2)
```

4. After adding cert/keys, please check if they are successfully stored.

```
[/DA16200/NET]# cert
#1 (MQTT, Enterprise)
Root CA: O
Certificate: O
Private Key: O
DH Parameter: X
#2 (HTTPs, CoAPs Client)
Root CA: X
Certificate: X
Private Key: X
DH Parameter: X
```

In case you want to remove all the credentials stored:

```
[/DA16200/NET]# cert 3
```



DA16200 MQTT Programmer Guide

6.2 CA, Client Cert, and Client Key

- Cert 0: CA

```

-----BEGIN CERTIFICATE-----
MIID+TCCAUGgAwIBAgIJANqgHCazDkkOMA0GCSqGSIb3DQEBCwUAMIGSMQswCQYD
VQQGEwJVUzETMBEGA1UECAwKQ2FsaWZvcn5pYTEUMBIGA1UEBwwLU2FudGEgQ2xh
cmExFzAVBgNVBAoMD1dpLUZpIEFsbG1hbnNlMR0wGwYDVQQDDBRXRkEgUm9vdCBD
ZXJ0aWZpY2F0ZTEgMB4GCSqGSIb3DQEJARYRc3VwcG9ydEB3aS1maS5vcmcwHhcN
MTMwMzExMTkwMjI2WhcNMjMwMzA5MTkwMjI2WjCBkjELMAKGA1UEBhMCVVMxEzAR
BgNVBAGMCKNhbG1mb3JuaWEeXFDASBgNVBACMC1NhbnRhIENsYXJhMRcwFQYDVQQK
DA5XaS1GaSBbbGxpYW5jZTEdMBSGA1UEAwwUV0ZBIFJvb3QgQ2VydGlmawNhdGUx
IDAeBgkqhkiG9w0BCQEWEXN1cHBvcnRAD2ktZmkub3JnMIIBIjANBgkqhkiG9w0B
AQEFAAOCAQ8AMIIBCgKCAQEA6TOCu20m+9zLZITYAhGmtxwyJQ/1xytXSQJYX8LN
YUS/N3HG2QAQ4GKDh7DPDI13zhdc0yOUE1CIOXa1ETKbHIU9xAbRl7KfX2HCQ1nC
PqRPiW9/wgQch8Aw7g/0rXmg1zewPJ36zKnq5/5Q1uyd8YfaXBzhxm1IY1wTKM1C
ixDFcAeVqHb74mAcde111xdagHvaL56fpUExm7GyMGXYd+Q2vYa/olUwCMGfMOj6
FLHwKpy62KCoK3016H1WU1bpg8YGpLDt2BB4LzxmPfyH2x+Xj75mAc1lOxx7GK0r
cGPPiNRsr4vgo1tm4Bh1eIW57h+gXoFfHCJLMG66uhU/2QIDAQABo1AwTjAdBgNV
HQ4EFgQUQCwPCPLSiKL0+Sd5y8V+Oqw6XZ4IwHwYDVR0jBBgwFoAUCwPCPLSiKL0+
Sd5y8V+Oqw6XZ4IwDAYDVR0TBAAUwAwEB/zANBgkqhkiG9w0BAQsFAAOCAQEAsNxO
z9DXb7TkNFKtPOY/7lZig4Ztdu6Lgf6qEUOvJGW/Bw1Wx1PMjPpk9oI+JdR8ZZ4B
9QhE+LZhg6SjBjK+VJqUCtVnXWdg0e8CgeUw718GNZithIE1WYK3Kh1cSo3sJt0P
z9CiJfjwtdBdwsdAqC9zV9tgp09QkEkav84X20VxaITa3H1QuK/LWSn/ORrzcX0I1
10YoF6 Hz3Zwa65mUoMzd8DyTcyGtcbYrSt+NMCGRB186PDQn5XBCygtgF8VuiCyyk
Z04hqHLzAFc21P9yhwKgi3BHD/Sep8fvr9y4VpMIqHQM2jaFPxY1VxhPSV+UHoE1
fCPitIJTp/iXi7uXTQ==
-----END CERTIFICATE-----
    
```

- Cert 1: Client Cert

```

-----BEGIN CERTIFICATE-----
MIIEBTCCAu2gAwIBAgICEEYwDQYJKoZIhvcNAQELBQAwZlIxZCZAJBgNVBAYTA1VT
MRMwEQYDVQQIDApDYWxpZm9ybmlhMRQwEgYDVQQHDAhTYW50YSBDbGFyYXJ0eXN1
A1UECgwOV2ktRmkgQWwSaWZvcn5pYTEUMBIGA1UEBwwLU2FudGEgQ2xhcmExFzAV
BgNVBAoMD1dpLUZpIEFsbG1hbnNlMR0wGwYDVQQDDBRXRkEgUm9vdCBDZXJ0aWZp
Y2F0ZTEgMB4GCSqGSIb3DQEJARYRc3VwcG9ydEB3aS1maS5vcmcwHhcNMTMwMzEx
MTkwMjI2WhcNMjMwMzA5MTkwMjI2WjCBkjELMAKGA1UEBhMCVVMxEzARBgNVBAGM
CKNhbG1mb3JuaWEeXFDASBgNVBACMC1NhbnRhIENsYXJhMRcwFQYDVQQKDA5XaS1
GaSBbbGxpYW5jZTEdMBSGA1UEAwwUV0ZBIFJvb3QgQ2VydGlmawNhdGUxIDAeBgk
qhkiG9w0BCQEWEXN1cHBvcnRAD2ktZmkub3JnMIIBIjANBgkqhkiG9w0BAQEFAAO
CAQ8AMIIBCgKCAQEA6TOCu20m+9zLZITYAhGmtxwyJQ/1xytXSQJYX8LNZYUS/N3
HG2QAQ4GKDh7DPDI13zhdc0yOUE1CIOXa1ETKbHIU9xAbRl7KfX2HCQ1nCPqRPi
W9/wgQch8Aw7g/0rXmg1zewPJ36zKnq5/5Q1uyd8YfaXBzhxm1IY1wTKM1CixDFc
AeVqHb74mAcde111xdagHvaL56fpUExm7GyMGXYd+Q2vYa/olUwCMGfMOj6FLHw
Kpy62KCoK3016H1WU1bpg8YGpLDt2BB4LzxmPfyH2x+Xj75mAc1lOxx7GK0rcGPP
iNRsr4vgo1tm4Bh1eIW57h+gXoFfHCJLMG66uhU/2QIDAQABo1AwTjAdBgNVHQ4
EFgQUQCwPCPLSiKL0+Sd5y8V+Oqw6XZ4IwHwYDVR0jBBgwFoAUCwPCPLSiKL0+S
d5y8V+Oqw6XZ4IwDAYDVR0TBAAUwAwEB/zANBgkqhkiG9w0BAQsFAAOCAQEAsNxO
z9DXb7TkNFKtPOY/7lZig4Ztdu6Lgf6qEUOvJGW/Bw1Wx1PMjPpk9oI+JdR8ZZ4B
9QhE+LZhg6SjBjK+VJqUCtVnXWdg0e8CgeUw718GNZithIE1WYK3Kh1cSo3sJt0P
z9CiJfjwtdBdwsdAqC9zV9tgp09QkEkav84X20VxaITa3H1QuK/LWSn/ORrzcX0I1
10YoF6 Hz3Zwa65mUoMzd8DyTcyGtcbYrSt+NMCGRB186PDQn5XBCygtgF8VuiCyyk
Z04hqHLzAFc21P9yhwKgi3BHD/Sep8fvr9y4VpMIqHQM2jaFPxY1VxhPSV+UHoE1
fCPitIJTp/iXi7uXTQ==
-----END CERTIFICATE-----
    
```

DA16200 MQTT Programmer Guide

- Cert 2: Client Key

```

-----BEGIN RSA PRIVATE KEY-----
MIIEpQIBAAKCAQEAA3KO5EOfTm/3wcNmYEgF1VgQpiVtMmsfCuvNpEYh5QdWieSjv
K0xJLWZTw0FYaDt1K/iI/WPLpA9x6gjGveU9Wty8vZYQyDBF1UakYGURmvxQv45I
ivbvUoCFz2aiZNBpYVRu2u3XgvAbyoqiBYV6B5dDeJyccFQFJGoOPHV2608azh9u
gvasFPQYkv3NaMxyTJqtOd1j0kGSCEqvP1ZsZQm218UO5FNqGZMQ61t4TCNzj0vN
LPKuLTM7orb8xTtCbwb4IeCBch08oJyBO/pTPX9xMMxAsPZxAXS+wL352C4ZSBCP
EvMGU1KZ3fFWOULO0GuKyzbqiNu92SFiS4fb/wIDAQABAoIBAQDcnbCc2mt5AM98
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-----END RSA PRIVATE KEY-----
    
```

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Linux kernel 3.9.0 rc3 version (backport 4.2.6-1)

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## DA16200 MQTT Programmer Guide

## Revision History

Revision	Date	Description
1.6	01-Apr-2021	SDK V3.x.x.x support added.
1.5	11-Mar-2021	Section 4.6 and Section 5.5.1 added. Section 4.5 cmd_mqtt_sample( ) updated. Symbol name change: from FC9K/fc9k to DA16X/da16x. mqtt_config long_password added. Terms updated; typo fixed. Figure labels added.
1.4	27-Nov-2020	Command "mqtt_config client_id" added.
1.3	30-Mar-2020	Several small updates.
1.2	26-Nov-2019	Finalized for publication.
1.1	15-Nov-2019	Editorial review.
1.0	30-Aug-2019	Preliminary DRAFT Release.

## DA16200 MQTT Programmer Guide

### Status Definitions

Status	Definition
DRAFT	The content of this document is under review and subject to formal approval, which may result in modifications or additions.
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