WLAN Integration Guide

Version Record

Date	Version	Description
2019-12-30	v0.93	First release
2020-03-05	v0.95	**Accesstoken** encryption description added
2020-03-21	v0.97	Updated **messageID** description
2020-03-31	v0.99	Updated interface description

Scope and Purpose

This guide introduces how to integrate motorized window covering products (For instance, Wi-Fi bridge & 433MHz Radio motors) into a 3rd party automation system via WLAN access.

Note: The 'Connector' APP must configure all of the setups include Bridge pairing and blinds adding. The 3rd party is unable to add/edit/delete the Wi-Fi bridge and the child devices/blinds. It only has child devices control permission via WLAN.

Definition

Client/Server

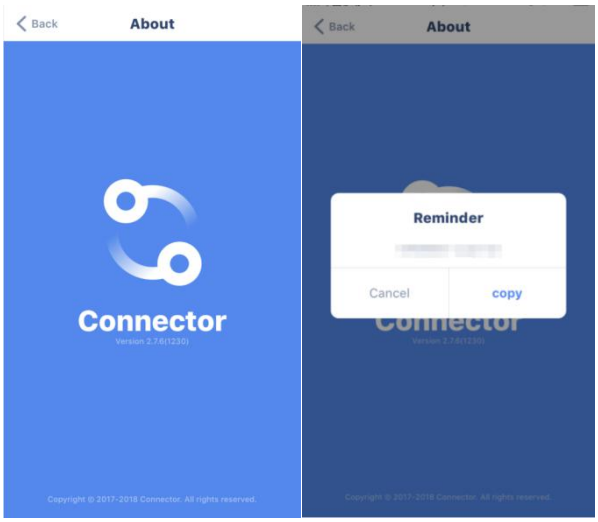
Client: Wi-Fi bridge

Server: The 3rd party automation system

KEY/**token**/**AccessToken**:

KEY is a 16-byte length string. It assigns by Connector APP. **KEY** and **token** use to create a 16-byte length **AccessToken**, **Client** responses only when it receives the correct **AccessToken**, the **AccessToken** algorithm reference is at the end of the document.

Please quickly tap the 'Connector APP About' page 5 times to get **KEY**.



token is a 16-byte length string. The **Server** can capture **token** in the interface '**Device discovering**' or '**Heartbeat**.'

Accesstoken calculation logic & reference

Please use the URL below to verify your encryption.

https://www.devglan.com/online-tools/aes-encryption-decryption

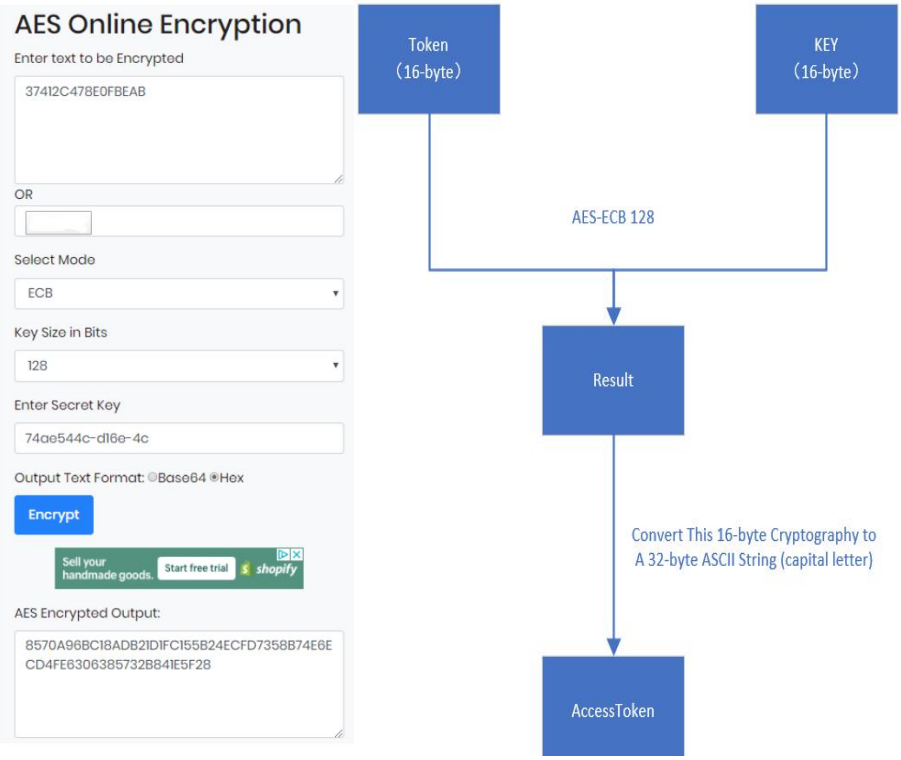
Fill **token** in 'Enter text to be Encrypted,' fill **KEY** in 'Enter Secret Key.' ('Select Mode' == 'ECB' ; 'Key Size in Bits' == '128'; 'Output Text Format' == 'Hex')

For example

token : 37412C478E0FBEAB

KEY : 74ae544c-d16e-4c

AccessToken : 8570A96BC18ADB21D1FC155B24ECFD73



The integration process

1. Device discovering using 'Get device list'.
2. Calculate '**Accesstoken**' using **KEY** and **token**.
3. Control child devices using 'Child device control', 'Child device status query', and 'Child device status report'.

Interface

Get device list

Get device list from Wi-Fi Bridge, includes Wi-Fi Bridge and child devices.

1. **Server** discovers Wi-Fi bridge & child devices using UDP unicast [Client_IP:32100] or UPD multicast [238.0.0.18:32100].
2. **Client** uploads lists by UDP unicast [Client_IP:32101].

Interface parameters:

Name	Type	Value	Description
msgType	String	**GetDeviceList**	Get device list
msgID	String		Message-ID (Timestamp)

Interface response

Name	Type	Value	Description
msgType	String	**GetDeviceListAck**	Upload device list
mac	String		Wi-Fi Bridge MAC address
deviceType	String		10000000: 433Mhz radio motor 22000000: Wi-Fi Curtain 02000001: Wi-Fi Bridge 22000002: Wi-Fi tubular motor 22000005:Wi-Fi receiver
ProtocolVersion	String		WLAN access protocol version
token	String		Token
data	JsonArray		Child device list

JsonArray

Name	Type	Value	Description
mac	String		Child device mac
deviceType	String		10000000: 433Mhz radio motor

Reference

Request data

```
// Server->[238.0.0.18:32100] or Server -> Client_IP:32100
{
    "msgType":"GetDeviceList",
    "msgID":"20200321134209916"
}
```

Response data

```
// Client->Server_IP:32101
{
    "msgType":"GetDeviceListAck",
    "mac":"500291b691fd",
    "deviceType":"02000001",
    "ProtocolVersion":"0.9",
    "token":"37412C478E0FBEAB",
    "data":[
        {
            "mac":"500291b691fd",
              "deviceType":"02000001"
        },
        {
            "mac":"500291b691fd005f",
              "deviceType":"10000000"
        },
        {
              "mac":"500291b691fd0060",
              "deviceType":"10000000"
        }
    ]
}
```

Heartbeat

Keep alive, **Client** heartbeats per 30~60 seconds using UPD multicast [238.0.0.18:32101].

Interface parameters:

Name	Type	Value	Description
msgType	String	**Heartbeat**	
mac	String		Wi-Fi Bridge MAC address
deviceType	String		Device application type 02000001: Wi-Fi Bridge 10000000: 433Mhz radio motor 22000000: Wi-Fi Curtain 22000002: Wi-Fi tubular motor 22000005:Wi-Fi receiver
token	String		Token
data	JsonArray		Info

JsonArray

Name	Type	Value	Description
currentState	enum	1|2|3	1 : Working 2 : Pairing 3 : Updating
numberOfDevices	Int		Number of Child devices
RSSI	Int		Wi-Fi connection strength

Reference

Response data

```
// Client->238.0.0.18:32101
{
    "msgType": "Heartbeat",
    "mac": "b4e62db27481",
    "deviceType": "02000001",
    "token": "37412C478E0FBEAB",
    "data": {
        "currentState": 1,
        "numberOfDevices": 3,
        "RSSI": -21
    }
}
```

Child-device control

Server controls child-devices using '**WriteDevice**' message. (UDP unicast [Client_IP:32100] or UPD multicast [238.0.0.18:32100])

Client response using '**WriteDeviceAck**', and returns the child-device current status. (UDP unicast [Server_IP:32101])

Interface parameters:

Name	Type	Value	Description
msgType	String	**WriteDevice**	Child-device control
mac	String		Message-ID (Timestamp)
deviceType	String		02000001: Wi-Fi Bridge 10000000: 433Mhz radio motor 22000000: Wi-Fi Curtain 22000002: Wi-Fi tubular motor 22000005:Wi-Fi receiver
AccessToken	String		
msgID	String		Timestamp
data	JsonArray		Control command

JsonArray

Name	Type	Value	Description
operation	enum	0|1|2|3|5	0: Close/Down 1: Open/Up 2: Stop 5: Status query
targetPosition	Int		0-100
targetAngle	Int		0-180

Interface response

Name	Type	Value	Description
msgType	String	**WriteDeviceAck**	
mac	String		Wi-Fi Bridge MAC address
deviceType	String		10000000: 433Mhz radio motor
data	JsonArray		

JsonArray

Name	Type	Value	Description
type	Int		1:Roller Blinds 2:Venetian Blinds 3:Roman Blinds 4:Honeycomb Blinds 5:Shangri-La Blinds 6:Roller Shutter 7:Roller Gate 8:Awning 9:TDBU 10:Day&night Blinds 11:Dimming Blinds 12:Curtain 13:Curtain(Open Left) 14:Curtain(Open Right
operation	enum	0|1|2|5	0: Close/Down 1: Open/Up 2: Stop 5: Status query
currentPosition	Int		0-100
currentAngle	Int		0-180
currentState	enum	0|1|2|3|4	0: No limits 1: Top-limit detected 2: Bottom-limit detected 3: Limits detected 4: 3rd -limit detected
voltageMode	enum	0|1	0: AC Motor 1: DC Motor
batteryLevel	Int		Power voltage (DC motor only)
wirelessMode	enum	0|1|2|3	0: Uni-direction 1: Bi-direction 2: Bi-direction (mechanical limits) 3:Others
RSSI	Int		Radio signal strength

Reference

Percentage control

Only bi-directional devices supported (wireless Mode == 1 required).

Request data

```
// Server->[238.0.0.18:32100] or Server->Client_IP:32100
{
	"msgType": "WriteDevice",
	"mac": "b4e62db27481001f",
	"deviceType": "10000000",
	"AccessToken": "0D5D443049491C20988B46AC54323BA2",
	"msgID": "20200331103919505",
	"data": {
		"targetPosition": 44
	}
}
```

Respond data

```
// Client->Server_IP:32101
{
	"msgType": "WriteDeviceAck",
	"mac": "b4e62db27481001f",
	"deviceType": "10000000",
	"data": {
		"type": 13,
		"operation": 2,
		"currentPosition": 59,
		"currentAngle": 180,
		"currentState": 3,
		"voltageMode": 0,
		"batteryLevel": 811,
		"wirelessMode": 1,
		"RSSI": -73
	}
}
```

Rotation/Angle control

Only bi-directional devices supported (wireless Mode == 1 required).

Request data

```
// Server->[238.0.0.18:32100] or Server->Client_IP:32100
{
	"msgType": "WriteDevice",
	"mac": "b4e62db27481001f",
```

```
        "deviceType": "10000000",
        "AccessToken": "0D5D443049491C20988B46AC54323BA2",
        "msgID": "20200331105628663",
        "data": {
                "targetAngle": 78
        }
}
```

Respond data

```
// Client->Server_IP:32101
{
        "msgType": "WriteDeviceAck",
        "mac": "b4e62db27481001f",
        "deviceType": "10000000",
        "data": {
                "type": 13,
                "operation": 0,
                "currentPosition": 44,
                "currentAngle": 0,
                "currentState": 3,
                "voltageMode": 0,
                "batteryLevel": 811,
                "wirelessMode": 1,
                "RSSI": -68
        }
}
```

Open/Up

Request data

```
// Server->[238.0.0.18:32100] or Server->Client_IP:32100
{
        "msgType": "WriteDevice",
        "mac": "b4e62db27481001f",
        "deviceType": "10000000",
        "AccessToken": "0D5D443049491C20988B46AC54323BA2",
        "msgID": "20200331105646317",
        "data": {
                "operation": 1
        }
}
```

Respond data

```
// Client->Server_IP:32101
{
    "msgType": "WriteDeviceAck",
    "mac": "b4e62db27481001f",
    "deviceType": "10000000",
    "data": {
        "type": 13,
        "operation": 2,
        "currentPosition": 47,
        "currentAngle": 77,
        "currentState": 3,
        "voltageMode": 0,
        "batteryLevel": 811,
        "wirelessMode": 1,
        "RSSI": -67
    }
}
```

Close/Down

Request data

```
// Server->[238.0.0.18:32100] or Server->Client_IP:32100
{
    "msgType": "WriteDevice",
    "mac": "b4e62db27481001f",
    "deviceType": "10000000",
    "AccessToken": "0D5D443049491C20988B46AC54323BA2",
    "msgID": "20200331105735705",
    "data": {
        "operation": 0
    }
}
```

Respond data

```
// Client->Server_IP:32101
{
    "msgType": "WriteDeviceAck",
    "mac": "b4e62db27481001f",
    "deviceType": "10000000",
    "data": {
        "type": 13,
        "operation": 2,
        "currentPosition": 0,
        "currentAngle": 0,
```

```
            "currentState": 3,
            "voltageMode": 0,
            "batteryLevel": 811,
            "wirelessMode": 1,
            "RSSI": -68
        }
}
```

Stop

Request data

```
// Server->[238.0.0.18:32100] or Server->Client_IP:32100
{
        "msgType": "WriteDevice",
        "mac": "b4e62db27481001f",
        "deviceType": "10000000",
        "AccessToken": "0D5D443049491C20988B46AC54323BA2",
        "msgID": "20200331105833122",
        "data": {
            "operation": 2
        }
}
```

Respond data

```
// Client->Server_IP:32101
{
        "msgType": "WriteDeviceAck",
        "mac": "b4e62db27481001f",
        "deviceType": "10000000",
        "data": {
            "type": 13,
            "operation": 2,
            "currentPosition": 100,
            "currentAngle": 180,
            "currentState": 3,
            "voltageMode": 0,
            "batteryLevel": 811,
            "wirelessMode": 1,
            "RSSI": -70
        }
}
```

Child-device status report

The child-device reports status after it stops running(UPD multicast [238.0.0.18:32101]).

Only bi-directional motor supported(wireless Mode == 1 required).

Interface parameters:

Name	Type	Value	Description
msgType	String	**Report**	Status report
mac	String		Message-ID (Timestamp)
deviceType	String		
data	JsonArray		

JsonArray

Name	Type	Value	Description
type	Int		1:Roller Blinds 2:Venetian Blinds 3:Roman Blinds 4:Honeycomb Blinds 5:Shangri-La Blinds 6:Roller Shutter 7:Roller Gate 8:Awning 9:TDBU 10:Day&night Blinds 11:Dimming Blinds 12:Curtain 13:Curtain(Open Left) 14:Curtain(Open Right
operation	enum	0|1|2|5	0: Close/Down 1: Open/Up 2: Stop 5: Status query
currentPosition	Int		0-100
currentAngle	Int		0-180
currentState	enum	0|1|2|3|4	0: Not limit 1: Top-limit detected 2: Bottom-limit detected 3: Limits detected 4: 3rd -limit detected
voltageMode	enum	0|1	0: AC Motor 1: DC Motor

batteryLevel	Int		Power voltage (DC motor only)
wirelessMode	enum	0|1|2|3	0: Uni-direction 1: Bi-direction 2: Bi-direction (mechanical limits) 3:Others
RSSI	Int		Radio signal strength

Reference

```
// Client->238.0.0.18:32101
{
	"msgType": "Report",
	"mac": "b4e62db27481001f",
	"deviceType": "10000000",
	"data": {
		"type": 13,
		"operation": 2,
		"currentPosition": 88,
		"currentAngle": 0,
		"currentState": 3,
		"voltageMode": 0,
		"batteryLevel": 811,
		"wirelessMode": 1,
		"RSSI": -71
	}
}
```

Child-device status query

Server query using `**ReadDevice**' message. (UDP unicast [Client_IP:32100] or UPD multicast [238.0.0.18:32100])

Client response using `**ReadDeviceAck**', and returns the child-device current status. (UDP unicast [Server_IP:32101])

Only bi-directional devices supported (wireless Mode == 1).

Interface parameters:

Name	Type	Value	Description
msgType	String	**ReadDevice**	Child-device control
mac	String		
deviceType	String		10000000: 433Mhz radio motor
msgID	String		Timestamp

Interface response

Name	Type	Value	Description
msgType	String	**ReadDeviceAck**	Status report
mac	String		
deviceType	String		10000000: 433Mhz radio motor
data	JsonArray		

JsonArray

Name	Type	Value	
type	Int		1:Roller Blinds 2:Venetian Blinds 3:Roman Blinds 4:Honeycomb Blinds 5:Shangri-La Blinds 6:Roller Shutter 7:Roller Gate 8:Awning 9:TDBU 10:Day&night Blinds 11:Dimming Blinds 12:Curtain 13:Curtain(Open Left) 14:Curtain(Open Right
operation	enum	0|1|2|5	0: Close/Down 1: Open/Up 2: Stop 5: Status query

currentPosition	Int		0-100
currentAngle	Int		0-180
currentState	enum	0|1|2|3|4	0: Not limit 1: Top-limit detected 2: Bottom-limit detected 3: Limits detected 4: 3rd -limit detected
voltageMode	enum	0|1	0: AC Motor 1: DC Motor
batteryLevel	Int		Power voltage (DC motor only)
wirelessMode	enum	0|1|2|3	0: Uni-direction 1: Bi-direction 2: Bi-direction (mechanical limits) 3:Others
RSSI	Int		Radio signal strength

Reference

Request data

```
// Server->[238.0.0.18:32100] or Server->Client_IP:32100
{
    "msgType": "ReadDevice",
    "mac": "b4e62db27481001f",
    "deviceType": "10000000",
    "msgID": "20200331105919505",
}
```

Respond data

```
// Client->238.0.0.18:32101
{
    "msgType": "ReadDeviceAck",
    "mac": "b4e62db27481001f",
    "deviceType": "10000000",
    "data": {
        "type": 13,
        "operation": 2,
        "currentPosition": 88,
        "currentAngle": 0,
        "currentState": 3,
        "voltageMode": 0,
        "batteryLevel": 811,
        "wirelessMode": 1,
        "RSSI": -71
    }
}
```

Encryption and decryption algorithm

Step1: Use **KEY**(From the `Connector APP About' page) to make an AES-ECB 128 encryption for the received **token** (the 16-byte length string from `**Device discovering**' or `**Heartbeat**') and create a 16 byte-length cryptograph。
Step2: Convert this 16-byte cryptography to a 32-byte ASCII string (capital letter)

The reference code

```
#include "stdint.h"
#include "stdio.h"
#include "mgOS.h"

// 0ptional length 128,192,256
#define AES_KEY_LENGTH   128

// Encryption & decryption mode
#define AES_MODE_ECB    0                       // Electronic codebook
#define AES_MODE_CBC    1                       // Cipher-block chaining
#define AES_MODE        AES_MODE_ECB


#define Nk    (AES_KEY_LENGTH / 32)             // Nk = 4, Key string length, 4 bytes (1 word)
#define Nb    4                                 // Nb = 4,

// Nr:Encryption rounds
#if     AES_KEY_LENGTH == 128
    #define Nr    10
#elif AES_KEY_LENGTH == 192
    #define Nr    12
#elif AES_KEY_LENGTH == 256
    #define Nr    14
#else
    #error AES_KEY_LENGTH must be 128, 192 or 256 bools!
#endif

// GF(28) polynomial
#define BPOLY 0x1B // Lower 8 bools of (x^8 + x^4 + x^3 + x + 1), ie. (x^4 + x^3 + x + 1).

// AES subkey table, it requires a 176 bytes space when using a 128-byte length key.
static    uint8_t g_roundKeyTable[4*Nb*(Nr+1)];

// Encryption SBox
static const const uint8_t SBox[256] =
{
    0x63, 0x7c, 0x77, 0x7b, 0xf2, 0x6b, 0x6f, 0xc5, 0x30, 0x01, 0x67, 0x2b, 0xfe, 0xd7, 0xab, 0x76,
    0xca, 0x82, 0xc9, 0x7d, 0xfa, 0x59, 0x47, 0xf0, 0xad, 0xd4, 0xa2, 0xaf, 0x9c, 0xa4, 0x72, 0xc0,
    0xb7, 0xfd, 0x93, 0x26, 0x36, 0x3f, 0xf7, 0xcc, 0x34, 0xa5, 0xe5, 0xf1, 0x71, 0xd8, 0x31, 0x15,
    0x04, 0xc7, 0x23, 0xc3, 0x18, 0x96, 0x05, 0x9a, 0x07, 0x12, 0x80, 0xe2, 0xeb, 0x27, 0xb2, 0x75,
    0x09, 0x83, 0x2c, 0x1a, 0x1b, 0x6e, 0x5a, 0xa0, 0x52, 0x3b, 0xd6, 0xb3, 0x29, 0xe3, 0x2f, 0x84,
    0x53, 0xd1, 0x00, 0xed, 0x20, 0xfc, 0xb1, 0x5b, 0x6a, 0xcb, 0xbe, 0x39, 0x4a, 0x4c, 0x58, 0xcf,
    0xd0, 0xef, 0xaa, 0xfb, 0x43, 0x4d, 0x33, 0x85, 0x45, 0xf9, 0x02, 0x7f, 0x50, 0x3c, 0x9f, 0xa8,
    0x51, 0xa3, 0x40, 0x8f, 0x92, 0x9d, 0x38, 0xf5, 0xbc, 0xb6, 0xda, 0x21, 0x10, 0xff, 0xf3, 0xd2,
    0xcd, 0x0c, 0x13, 0xec, 0x5f, 0x97, 0x44, 0x17, 0xc4, 0xa7, 0x7e, 0x3d, 0x64, 0x5d, 0x19, 0x73,
    0x60, 0x81, 0x4f, 0xdc, 0x22, 0x2a, 0x90, 0x88, 0x46, 0xee, 0xb8, 0x14, 0xde, 0x5e, 0x0b, 0xdb,
    0xe0, 0x32, 0x3a, 0x0a, 0x49, 0x06, 0x24, 0x5c, 0xc2, 0xd3, 0xac, 0x62, 0x91, 0x95, 0xe4, 0x79,
    0xe7, 0xc8, 0x37, 0x6d, 0x8d, 0xd5, 0x4e, 0xa9, 0x6c, 0x56, 0xf4, 0xea, 0x65, 0x7a, 0xae, 0x08,
    0xba, 0x78, 0x25, 0x2e, 0x1c, 0xa6, 0xb4, 0xc6, 0xe8, 0xdd, 0x74, 0x1f, 0x4b, 0xbd, 0x8b, 0x8a,
    0x70, 0x3e, 0xb5, 0x66, 0x48, 0x03, 0xf6, 0x0e, 0x61, 0x35, 0x57, 0xb9, 0x86, 0xc1, 0x1d, 0x9e,
    0xe1, 0xf8, 0x98, 0x11, 0x69, 0xd9, 0x8e, 0x94, 0x9b, 0x1e, 0x87, 0xe9, 0xce, 0x55, 0x28, 0xdf,
    0x8c, 0xa1, 0x89, 0x0d, 0xbf, 0xe6, 0x42, 0x68, 0x41, 0x99, 0x2d, 0x0f, 0xb0, 0x54, 0xbb, 0x16
};
```

```
// Decryption SBox
static const const uint8_t InvSBox[256] =
{
    0x52, 0x09, 0x6a, 0xd5, 0x30, 0x36, 0xa5, 0x38, 0xbf, 0x40, 0xa3, 0x9e, 0x81, 0xf3, 0xd7, 0xfb,
    0x7c, 0xe3, 0x39, 0x82, 0x9b, 0x2f, 0xff, 0x87, 0x34, 0x8e, 0x43, 0x44, 0xc4, 0xde, 0xe9, 0xcb,
    0x54, 0x7b, 0x94, 0x32, 0xa6, 0xc2, 0x23, 0x3d, 0xee, 0x4c, 0x95, 0x0b, 0x42, 0xfa, 0xc3, 0x4e,
    0x08, 0x2e, 0xa1, 0x66, 0x28, 0xd9, 0x24, 0xb2, 0x76, 0x5b, 0xa2, 0x49, 0x6d, 0x8b, 0xd1, 0x25,
    0x72, 0xf8, 0xf6, 0x64, 0x86, 0x68, 0x98, 0x16, 0xd4, 0xa4, 0x5c, 0xcc, 0x5d, 0x65, 0xb6, 0x92,
    0x6c, 0x70, 0x48, 0x50, 0xfd, 0xed, 0xb9, 0xda, 0x5e, 0x15, 0x46, 0x57, 0xa7, 0x8d, 0x9d, 0x84,
    0x90, 0xd8, 0xab, 0x00, 0x8c, 0xbc, 0xd3, 0x0a, 0xf7, 0xe4, 0x58, 0x05, 0xb8, 0xb3, 0x45, 0x06,
    0xd0, 0x2c, 0x1e, 0x8f, 0xca, 0x3f, 0x0f, 0x02, 0xc1, 0xaf, 0xbd, 0x03, 0x01, 0x13, 0x8a, 0x6b,
    0x3a, 0x91, 0x11, 0x41, 0x4f, 0x67, 0xdc, 0xea, 0x97, 0xf2, 0xcf, 0xce, 0xf0, 0xb4, 0xe6, 0x73,
    0x96, 0xac, 0x74, 0x22, 0xe7, 0xad, 0x35, 0x85, 0xe2, 0xf9, 0x37, 0xe8, 0x1c, 0x75, 0xdf, 0x6e,
    0x47, 0xf1, 0x1a, 0x71, 0x1d, 0x29, 0xc5, 0x89, 0x6f, 0xb7, 0x62, 0x0e, 0xaa, 0x18, 0xbe, 0x1b,
    0xfc, 0x56, 0x3e, 0x4b, 0xc6, 0xd2, 0x79, 0x20, 0x9a, 0xdb, 0xc0, 0xfe, 0x78, 0xcd, 0x5a, 0xf4,
    0x1f, 0xdd, 0xa8, 0x33, 0x88, 0x07, 0xc7, 0x31, 0xb1, 0x12, 0x10, 0x59, 0x27, 0x80, 0xec, 0x5f,
    0x60, 0x51, 0x7f, 0xa9, 0x19, 0xb5, 0x4a, 0x0d, 0x2d, 0xe5, 0x7a, 0x9f, 0x93, 0xc9, 0x9c, 0xef,
    0xa0, 0xe0, 0x3b, 0x4d, 0xae, 0x2a, 0xf5, 0xb0, 0xc8, 0xeb, 0xbb, 0x3c, 0x83, 0x53, 0x99, 0x61,
    0x17, 0x2b, 0x04, 0x7e, 0xba, 0x77, 0xd6, 0x26, 0xe1, 0x69, 0x14, 0x63, 0x55, 0x21, 0x0c, 0x7d
};


//================================================================================
//  Function:       RotationWord
//  Description:    Cyclic right shift of "word" data
//  Input:          pWord -- 4-byte data to be shifted to the right
//  Output:         pWord -- 4-byte data after right shift
//  Return:         Null
//================================================================================
static void RotationWord(uint8_t *pWord)
{
    uint8_t temp = pWord[0];
    pWord[0]  = pWord[1];
    pWord[1]  = pWord[2];
    pWord[2]  = pWord[3];
    pWord[3]  = temp;
}

//================================================================================
//  Function:       XorBytes
//  Description:        Batch XOR two sets of data
//  Input:      pData1 -- The first set of data to be XORed
//                      pData1 -- The second set of data to be XORed
//                      nCount -- Data length to XOR
//  Output:     pData1 -- The result after XOR
//  Return:       Null
//================================================================================
static void XorBytes(uint8_t *pData1, const uint8_t *pData2, uint8_t nCount)
{
    uint8_t i;

    for (i = 0; i < nCount; i++)
    {
        pData1[i] ^= pData2[i];
    }
}

//================================================================================
//  Function:       AddRoundKey
//  Description:        Add (exclusive OR) subkey to the intermediate state data, the data length is 16 bytes
//  Input:      pState      -- Status data
//                pRoundKey -- subkey data
//  Output:     pState      -- State data after subkey
//  Return:     Null
//================================================================================
static void AddRoundKey(uint8_t *pState, const uint8_t *pRoundKey)
{
    XorBytes(pState, pRoundKey, 4*Nb);
```

```
}

//=============================================================================
//  Function:       SubBytes
//  Description:        Replace state data with S box
//  Input:      pState    -- Status data
//                  nCount    -- subkey    data
//                  bInvert -- Whether to use the reverse S box (used when decrypting)
//  Output:     pState    -- Status data after replacement.
//  Return:       Null
//=============================================================================
static void SubBytes(uint8_t *pState, uint8_t nCount, bool bInvert)
{
    uint8_t i;
    const uint8_t const *pSBox = bInvert ? InvSBox : SBox;

    for (i = 0; i < nCount; i++)
    {
        pState[i] = pSBox[pState[i]];
    }
}

//=============================================================================
//  Function:       ShiftRows
//  Description:        Row migration status data
//  Input:      pState    -- Status data
//                  bInvert -- Whether to move backwards (used when decrypting).
//  Output:     pState    -- Status data after row migration.
//  Return:       Null。   Null
//=============================================================================
static void ShiftRows(uint8_t *pState, bool bInvert)
{
    // Note: Status data stored as `row'
    uint8_t r;      // row
    uint8_t c;      // column
    uint8_t temp;
    uint8_t rowData[4];

    for (r = 1; r < 4; r++)
    {
        // Back up one row of data
        for (c = 0; c < 4; c++)
        {
            rowData[c] = pState[r + 4*c];
        }

        temp = bInvert ? (4 - r) : r;
        for (c = 0; c < 4; c++)
        {
            pState[r + 4*c] = rowData[(c + temp) % 4];
        }
    }
}

//=============================================================================
//  Function:       GfMultBy02
//  Description:        Multiplication by 2 in GF (28)
//  Input:      num -- multiplier
//  Output:     Null
//  Return:     The result of num multiplied by 2
//=============================================================================
static uint8_t GfMultBy02(uint8_t num)
{
    if ((num & 0x80) == 0)
    {
        num = num << 1;
    }
    else
    {
```

```
            num = (num << 1) ^ BPOLY;
        }

        return num;
}

//=============================================================================
//  Function:       MixColumns
//  Description:        Mixed state column data
//  Input:      pState    -- Status data
//                      bInvert -- Whether to mix backwards (used when decrypting).
//  Output:     pState    -- State data after mixing columns
//  Return:       Null
//=============================================================================
static void MixColumns(uint8_t *pState, bool bInvert)
{
        uint8_t i;
        uint8_t temp;
        uint8_t a0Pa2_M4; // 4(a0 + a2)
        uint8_t a1Pa3_M4; // 4(a1 + a3)
        uint8_t result[4];

        for (i = 0; i < 4; i++, pState += 4)
        {
            temp = pState[0] ^ pState[1] ^ pState[2] ^ pState[3];
            result[0] = temp ^ pState[0] ^ GfMultBy02((uint8_t) (pState[0] ^ pState[1]));
            result[1] = temp ^ pState[1] ^ GfMultBy02((uint8_t) (pState[1] ^ pState[2]));
            result[2] = temp ^ pState[2] ^ GfMultBy02((uint8_t) (pState[2] ^ pState[3]));
            result[3] = temp ^ pState[3] ^ GfMultBy02((uint8_t) (pState[3] ^ pState[0]));

            if (bInvert)
            {
                a0Pa2_M4 = GfMultBy02(GfMultBy02((uint8_t) (pState[0] ^ pState[2])));
                a1Pa3_M4 = GfMultBy02(GfMultBy02((uint8_t) (pState[1] ^ pState[3])));
                temp     = GfMultBy02((uint8_t) (a0Pa2_M4 ^ a1Pa3_M4));
                result[0] ^= temp ^ a0Pa2_M4;
                result[1] ^= temp ^ a1Pa3_M4;
                result[2] ^= temp ^ a0Pa2_M4;
                result[3] ^= temp ^ a1Pa3_M4;
            }

            memcpy(pState, result, 4);
        }
}

//=============================================================================
//  Function:       BlockEncrypt
//  Description:        Encrypt single block data
//  Input:      pState -- Status data
//  Output:     pState -- Encrypted status data
//  Return:       Null
//=============================================================================
static void BlockEncrypt(uint8_t *pState)
{
        uint8_t i;

        AddRoundKey(pState, g_roundKeyTable);

        for (i = 1; i <= Nr; i++)       // i = [1, Nr]
        {
            SubBytes(pState, 4*Nb, 0);
            ShiftRows(pState, 0);

            if (i != Nr)
            {
                MixColumns(pState, 0);
            }

            AddRoundKey(pState, &g_roundKeyTable[4*Nb*i]);
```

```
    }
}

//=====================================================================
//  Function:       BlockDecrypt
//  Description:        Decrypt single block data
//  Input:      pState -- Status data
//  Output:     pState -- Decrypted single block data
//  Return:       Null
//=====================================================================
static void BlockDecrypt(uint8_t *pState)
{
    uint8_t i;

    AddRoundKey(pState, &g_roundKeyTable[4*Nb*Nr]);

    for (i = Nr; i > 0; i--) // i = [Nr, 1]
    {
        ShiftRows(pState, 1);
        SubBytes(pState, 4*Nb, 1);
        AddRoundKey(pState, &g_roundKeyTable[4*Nb*(i-1)]);

        if (i != 1)
        {
            MixColumns(pState, 1);
        }
    }
}


//=====================================================================
//  Function:       AES_Init
//  Description:        Initialize, perform extended key operations here
//  Input:      pKey -- The original key, it must be AES_KEY_LENGTH/8 bytes long.
//  Output:     Null
//  Return:     Null
//=====================================================================
void AES_Init(const void *pKey)
{
    // Extended key
    uint8_t i;
    uint8_t *pRoundKey;
    uint8_t Rcon[4] = {0x01, 0x00, 0x00, 0x00};

    memcpy(g_roundKeyTable, pKey, 4*Nk);

    pRoundKey = &g_roundKeyTable[4*Nk];

    for (i = Nk; i < Nb*(Nr+1); pRoundKey += 4, i++)
    {
        memcpy(pRoundKey, pRoundKey - 4, 4);

        if (i % Nk == 0)
        {
            RotationWord(pRoundKey);
            SubBytes(pRoundKey, 4, 0);
            XorBytes(pRoundKey, Rcon, 4);

            Rcon[0] = GfMultBy02(Rcon[0]);
        }
        else if (Nk > 6 && i % Nk == Nb)
        {
            SubBytes(pRoundKey, 4, 0);
        }

        XorBytes(pRoundKey, pRoundKey - 4*Nk, 4);
    }
}
```

```
//=============================================================================
//  Function:       AES_Encrypt
//  Description:        Encrypted data
//  Input:      pPlainText    -- Plain text, the data to be encrypted, whose length is nDataLen bytes.
//                      nDataLen        -- The data length, in bytes, must be an integral multiple of AES_KEY_LENGTH/8.
//                      pIV             -- Initialization vector, if using ECB mode, can be set to NULL.
//  Output:     pCipherText -- The ciphertext, which is encrypted by plaintext, can be the same as pPlainText.
//  Return:       Null。 Null
//=============================================================================
#if AES_MODE == AES_MODE_CBC
void AES_Encrypt(const uint8_t *pPlainText, uint8_t *pCipherText,uint16_t nDataLen, const uint8_t *pIV)
{
    uint16_t i;

    if (pPlainText != pCipherText)
    {
        memcpy(pCipherText, pPlainText, nDataLen);
    }

    for (i = nDataLen/(4*Nb); i > 0 ; i--, pCipherText += 4*Nb)
    {
        XorBytes(pCipherText, pIV, 4*Nb);
        BlockEncrypt(pCipherText);
        pIV = pCipherText;
    }
}
#else
void AES_Encrypt(const uint8_t *pPlainText, uint8_t *pCipherText,uint16_t nDataLen)
{
    uint16_t i;

    if (pPlainText != pCipherText)
    {
        memcpy(pCipherText, pPlainText, nDataLen);
    }

    for (i = nDataLen/(4*Nb); i > 0 ; i--, pCipherText += 4*Nb)
    {
        BlockEncrypt(pCipherText);
    }
}
#endif


//=============================================================================
//  Function:       AES_Decrypt
//  Description:        Decrypt data
//  Input:      pCipherText -- Ciphertext, the data to be decrypted, is nDataLen bytes in length.
//                      nDataLen        -- The data length, in bytes, must be an integral multiple of AES_KEY_LENGTH/8.
//                      pIV             -- Initialization vector, if using ECB mode, can be set to NULL.
//  Output:     pPlainText    -- Plain text, that is, the data decrypted by ciphertext, can be the same as pCipherText.
//  Return:       Null
//=============================================================================
#if AES_MODE == AES_MODE_CBC
void AES_Decrypt(uint8_t *pPlainText, const uint8_t *pCipherText,uint16_t nDataLen, const uint8_t *pIV)
{
    uint16_t i;

    if (pPlainText != pCipherText)
    {
        memcpy(pPlainText, pCipherText, nDataLen);
    }

    // Decrypt from the last piece of data, so there is no need to open up space to save IV
    pPlainText += nDataLen - 4*Nb;
    for (i = nDataLen/(4*Nb); i > 0 ; i--, pPlainText -= 4*Nb)
    {
        BlockDecrypt(pPlainText);
```

```
            if (i == 1)
            {     // Last block of data
                  XorBytes(pPlainText, pIV, 4*Nb);
            }
            else
            {
                  XorBytes(pPlainText, pPlainText - 4*Nb, 4*Nb);
            }
      }
}
#else
void AES_Decrypt(uint8_t *pPlainText, const uint8_t *pCipherText,uint16_t nDataLen)
{
      uint16_t i;

      if (pPlainText != pCipherText)
      {
            memcpy(pPlainText, pCipherText, nDataLen);
      }

      // Decrypt from the last piece of data, so there is no need to open up space to save IV
      pPlainText += nDataLen - 4*Nb;
      for (i = nDataLen/(4*Nb); i > 0 ; i--, pPlainText -= 4*Nb)
      {
            BlockDecrypt(pPlainText);
      }
}
#endif

//Encryption
void mgAesEncrypt(uint8_t *in,uint8_t *out,uint8_t *key,int length)
{
      AES_Init(key);
      AES_Encrypt(in, out, length);
}

//Decryption
void    mgAesDecrypt(uint8_t *in,uint8_t*out,uint8_t *key, int length)
{
      AES_Init(key);
      AES_Decrypt(out, in, length);
}

static void test()
{
      // Test AES algorithm
      char KEY[]      = "Q2W3E4R5T6Y7U8I9";
      char token[] = "5Axy9la9kR0tFTFs";
      char AccessToken[17] = {0};

      uint8_t O[16];

      mgAesEncrypt((uint8_t *)token, O, (uint8_t *)KEY, 16);

      sprintf(
            AccessToken,
            "%02X%02X%02X%02X%02X%02X%02X%02X%02X%02X%02X%02X%02X%02X%02X%02X",
            O[0],O[1],O[2],O[3],O[4],O[5],O[6],O[7],O[8],O[9],O[10],O[11],O[12],O[13],O[14],O[15]);

      printf("AccessToken:%s",AccessToken);
}
```