Python program to implement AES algorithm.

Program:

Plaintext = 0b1101011100101000

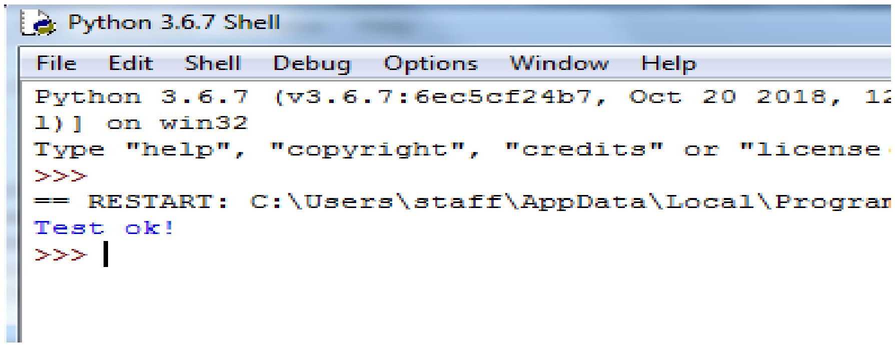
Key = 0b0100101011110101

```
import sys


# S-Box
sBox  = [0x9, 0x4, 0xa, 0xb, 0xd, 0x1, 0x8, 0x5,
        0x6, 0x2, 0x0, 0x3, 0xc, 0xe, 0xf, 0x7]


# Inverse S-Box
sBoxI = [0xa, 0x5, 0x9, 0xb, 0x1, 0x7, 0x8, 0xf,
        0x6, 0x0, 0x2, 0x3, 0xc, 0x4, 0xd, 0xe]


# Round keys: K0 = w0 + w1; K1 = w2 + w3; K2 = w4 + w5
w = [None] * 6


def mult(p1, p2):
    """Multiply two polynomials in GF(2^4)/x^4 + x + 1"""
    p = 0
    while p2:
        if p2 & 0b1:
            p ^= p1
        p1 <<= 1
        if p1 & 0b10000:
            p1 ^= 0b11
        p2 >>= 1
    return p & 0b1111
```

```
def intToVec(n):
    """Convert a 2-byte integer into a 4-element vector"""
    return [n >> 12, (n >> 4) & 0xf, (n >> 8) & 0xf,  n & 0xf]

def vecToInt(m):
    """Convert a 4-element vector into 2-byte integer"""
    return (m[0] << 12) + (m[2] << 8) + (m[1] << 4) + m[3]

def addKey(s1, s2):
    """Add two keys in GF(2^4)"""
    return [i ^ j for i, j in zip(s1, s2)]

def sub4NibList(sbox, s):
    """Nibble substitution function"""
    return [sbox[e] for e in s]

def shiftRow(s):
    """ShiftRow function"""
    return [s[0], s[1], s[3], s[2]]

def keyExp(key):
    """Generate the three round keys"""
    def sub2Nib(b):
        """Swap each nibble and substitute it using sBox"""
        return sBox[b >> 4] + (sBox[b & 0x0f] << 4)

    Rcon1, Rcon2 = 0b10000000, 0b00110000
    w[0] = (key & 0xff00) >> 8
    w[1] = key & 0x00ff
    w[2] = w[0] ^ Rcon1 ^ sub2Nib(w[1])
    w[3] = w[2] ^ w[1]
    w[4] = w[2] ^ Rcon2 ^ sub2Nib(w[3])
    w[5] = w[4] ^ w[3]

def encrypt(ptext):
    """Encrypt plaintext block"""
    def mixCol(s):
        return [s[0] ^ mult(4, s[2]), s[1] ^ mult(4, s[3]),
                s[2] ^ mult(4, s[0]), s[3] ^ mult(4, s[1])]

    state = intToVec(((w[0] << 8) + w[1]) ^ ptext)
    state = mixCol(shiftRow(sub4NibList(sBox, state)))
    state = addKey(intToVec((w[2] << 8) + w[3]), state)
    state = shiftRow(sub4NibList(sBox, state))
    return vecToInt(addKey(intToVec((w[4] << 8) + w[5]), state))

def decrypt(ctext):
    """Decrypt ciphertext block"""
    def iMixCol(s):
        return [mult(9, s[0]) ^ mult(2, s[2]), mult(9, s[1]) ^ mult(2, s[3]),
                mult(9, s[2]) ^ mult(2, s[0]), mult(9, s[3]) ^ mult(2, s[1])]

    state = intToVec(((w[4] << 8) + w[5]) ^ ctext)
    state = sub4NibList(sBoxI, shiftRow(state))
    state = iMixCol(addKey(intToVec((w[2] << 8) + w[3]), state))
    state = sub4NibList(sBoxI, shiftRow(state))
    return vecToInt(addKey(intToVec((w[0] << 8) + w[1]), state))
```

```
if __name__ == '__main__':
    # Test vectors from "Simplified AES"

    plaintext = 0b1101011100101000
    key = 0b0100101011110101
    ciphertext = 0b0010010011101100
    keyExp(key)
    try:
        assert encrypt(plaintext) == ciphertext
    except AssertionError:
        print("Encryption error")
        print(encrypt(plaintext), ciphertext)
        sys.exit(1)
    try:
        assert decrypt(ciphertext) == plaintext
    except AssertionError:
        print("Decryption error")
        print(decrypt(ciphertext), plaintext)
        sys.exit(1)
    print("Test ok!")
    sys.exit()
```

Output:



```
Python 3.6.7 (v3.6.7:6ec5cf24b7, Oct 20 2018, 1
1)] on win32
Type "help", "copyright", "credits" or "license
>>>
== RESTART: C:\Users\staff\AppData\Local\Progra
Test ok!
>>> 
```