

Advanced Encryption Standard (AES) Key Wrap Algorithm

Status of this Memo

This memo provides information for the Internet community. It does not specify an Internet standard of any kind. Distribution of this memo is unlimited.

Copyright Notice

Copyright (C) The Internet Society (2002). All Rights Reserved.

Abstract

The purpose of this document is to make the Advanced Encryption Standard (AES) Key Wrap algorithm conveniently available to the Internet community. The United States of America has adopted AES as the new encryption standard. The AES Key Wrap algorithm will probably be adopted by the USA for encryption of AES keys. The authors took most of the text in this document from the draft AES Key Wrap posted by NIST.

Table of Contents

1. Introduction.....	2
2. Overview.....	2
2.1 Notation and Definitions.....	3
2.2 Algorithms.....	4
2.2.1 Key Wrap.....	4
2.2.2 Key Unwrap.....	5
2.2.3 Key Data Integrity -- the Initial Value.....	6
2.2.3.1 Default Initial Value.....	7
2.2.3.2 Alternative Initial Values.....	7
3. Object Identifiers.....	8
4. Test Vectors.....	8
4.1 Wrap 128 bits of Key Data with a 128-bit KEK.....	8
4.2 Wrap 128 bits of Key Data with a 192-bit KEK.....	11
4.3 Wrap 128 bits of Key Data with a 256-bit KEK.....	14
4.4 Wrap 192 bits of Key Data with a 192-bit KEK.....	17
4.5 Wrap 192 bits of Key Data with a 256-bit KEK.....	24
4.6 Wrap 256 bits of Key Data with a 256-bit KEK.....	30

5. Security Considerations.....	39
6. References.....	39
7. Acknowledgments.....	39
8. Authors' Addresses.....	39
9. Full Copyright Statement.....	40

1. Introduction

NOTE: Most of the following text is taken from [AES-WRAP], and the assertions regarding the security of the AES Key Wrap algorithm are made by the US Government, not by the authors of this document.

This specification is intended to satisfy the National Institute of Standards and Technology (NIST) Key Wrap requirement to: Design a cryptographic algorithm called a Key Wrap that uses the Advanced Encryption Standard (AES) as a primitive to securely encrypt plaintext key(s) with any associated integrity information and data, such that the combination could be longer than the width of the AES block size (128-bits). Each ciphertext bit should be a highly non-linear function of each plaintext bit, and (when unwrapping) each plaintext bit should be a highly non-linear function of each ciphertext bit. It is sufficient to approximate an ideal pseudorandom permutation to the degree that exploitation of undesirable phenomena is as unlikely as guessing the AES engine key.

This key wrap algorithm needs to provide ample security to protect keys in the context of prudently designed key management architecture.

Throughout this document, any data being wrapped will be referred to as the key data. It makes no difference to the algorithm whether the data being wrapped is a key; in fact there is often good reason to include other data with the key, to wrap multiple keys together, or to wrap data that isn't strictly a key. So, the term "key data" is used broadly to mean any data being wrapped, but particularly keys, since this is primarily a key wrap algorithm. The key used to do the wrapping will be referred to as the key-encryption key (KEK).

In this document a KEK can be any valid key supported by the AES codebook. That is, a KEK can be a 128-bit key, a 192-bit key, or a 256-bit key.

2. Overview

The AES key wrap algorithm is designed to wrap or encrypt key data. The key wrap operates on blocks of 64 bits. Before being wrapped, the key data is parsed into n blocks of 64 bits.

The only restriction the key wrap algorithm places on n is that n be at least two. (For key data with length less than or equal to 64 bits, the constant field used in this specification and the key data form a single 128-bit codebook input making this key wrap unnecessary.) The key wrap algorithm accommodates all supported AES key sizes. However, other cryptographic values often need to be wrapped. One such value is the seed of the random number generator for DSS. This seed value requires n to be greater than four. Undoubtedly other values require this type of protection. Therefore, no upper bound is imposed on n .

The AES key wrap can be configured to use any of the three key sizes supported by the AES codebook. The choice of a key size affects the overall security provided by the key wrap, but it does not alter the description of the key wrap algorithm. Therefore, in the description that follows, the key wrap is described generically; no key size is specified for the KEK.

2.1 Notation and Definitions

The following notation is used in the description of the key wrapping algorithms:

AES(K , W)	Encrypt W using the AES codebook with key K
AES-1(K , W)	Decrypt W using the AES codebook with key K
MSB(j , W)	Return the most significant j bits of W
LSB(j , W)	Return the least significant j bits of W
$B1 \wedge B2$	The bitwise exclusive or (XOR) of $B1$ and $B2$
$B1 \parallel B2$	Concatenate $B1$ and $B2$
K	The key-encryption key K
n	The number of 64-bit key data blocks
s	The number of steps in the wrapping process, $s = 6n$
$P[i]$	The i th plaintext key data block
$C[i]$	The i th ciphertext data block
A	The 64-bit integrity check register
$R[i]$	An array of 64-bit registers where $i = 0, 1, 2, \dots, n$
$A[t]$, $R[i][t]$	The contents of registers A and $R[i]$ after encryption step t .
IV	The 64-bit initial value used during the wrapping process.

In the key wrap algorithm, the concatenation function will be used to concatenate 64-bit quantities to form the 128-bit input to the AES codebook. The extraction functions will be used to split the 128-bit output from the AES codebook into two 64-bit quantities.

2.2 Algorithms

The specification of the key wrap algorithm requires the use of the AES codebook [AES]. The next three sections will describe the key wrap algorithm, the key unwrap algorithm, and the inherent data integrity check.

2.2.1 Key Wrap

The inputs to the key wrapping process are the KEK and the plaintext to be wrapped. The plaintext consists of n 64-bit blocks, containing the key data being wrapped. The key wrapping process is described below.

Inputs: Plaintext, n 64-bit values $\{P_1, P_2, \dots, P_n\}$, and
Key, K (the KEK).
Outputs: Ciphertext, $(n+1)$ 64-bit values $\{C_0, C_1, \dots, C_n\}$.

1) Initialize variables.

```
Set A0 to an initial value (see 2.2.3)
For i = 1 to n
    R[0][i] = P[i]
```

2) Calculate intermediate values.

```
For t = 1 to s, where s = 6n
    A[t] = MSB(64, AES(K, A[t-1] | R[t-1][1])) ^ t
    For i = 1 to n-1
        R[t][i] = R[t-1][i+1]
    R[t][n] = LSB(64, AES(K, A[t-1] | R[t-1][1]))
```

3) Output the results.

```
Set C[0] = A[t]
For i = 1 to n
    C[i] = R[t][i]
```

An alternative description of the key wrap algorithm involves indexing rather than shifting. This approach allows one to calculate the wrapped key in place, avoiding the rotation in the previous description. This produces identical results and is more easily implemented in software.

Inputs: Plaintext, n 64-bit values $\{P_1, P_2, \dots, P_n\}$, and
 Key, K (the KEK).
 Outputs: Ciphertext, $(n+1)$ 64-bit values $\{C_0, C_1, \dots, C_n\}$.

1) Initialize variables.

```
Set A = IV, an initial value (see 2.2.3)
For i = 1 to n
  R[i] = P[i]
```

2) Calculate intermediate values.

```
For j = 0 to 5
  For i=1 to n
    B = AES(K, A | R[i])
    A = MSB(64, B) ^ t where t = (n*j)+i
    R[i] = LSB(64, B)
```

3) Output the results.

```
Set C[0] = A
For i = 1 to n
  C[i] = R[i]
```

2.2.2 Key Unwrap

The inputs to the unwrap process are the KEK and $(n+1)$ 64-bit blocks of ciphertext consisting of previously wrapped key. It returns n blocks of plaintext consisting of the n 64-bit blocks of the decrypted key data.

Inputs: Ciphertext, $(n+1)$ 64-bit values $\{C_0, C_1, \dots, C_n\}$, and
 Key, K (the KEK).
 Outputs: Plaintext, n 64-bit values $\{P_1, P_2, \dots, P_n\}$.

1) Initialize variables.

```
Set A[s] = C[0] where s = 6n
For i = 1 to n
  R[s][i] = C[i]
```

2) Calculate the intermediate values.

```
For t = s to 1
  A[t-1] = MSB(64, AES-1(K, ((A[t] ^ t) | R[t][n])))
  R[t-1][1] = LSB(64, AES-1(K, ((A[t]^t) | R[t][n])))
  For i = 2 to n
    R[t-1][i] = R[t][i-1]
```

3) Output the results.

```
If A[0] is an appropriate initial value (see 2.2.3),
Then
    For i = 1 to n
        P[i] = R[0][i]
Else
    Return an error
```

The unwrap algorithm can also be specified as an index based operation, allowing the calculations to be carried out in place. Again, this produces the same results as the register shifting approach.

Inputs: Ciphertext, (n+1) 64-bit values {C0, C1, ..., Cn}, and Key, K (the KEK).

Outputs: Plaintext, n 64-bit values {P0, P1, K, Pn}.

1) Initialize variables.

```
Set A = C[0]
For i = 1 to n
    R[i] = C[i]
```

2) Compute intermediate values.

```
For j = 5 to 0
    For i = n to 1
        B = AES-1(K, (A ^ t) | R[i]) where t = n*j+i
        A = MSB(64, B)
        R[i] = LSB(64, B)
```

3) Output results.

```
If A is an appropriate initial value (see 2.2.3),
Then
    For i = 1 to n
        P[i] = R[i]
Else
    Return an error
```

2.2.3 Key Data Integrity -- the Initial Value

The initial value (IV) refers to the value assigned to A[0] in the first step of the wrapping process. This value is used to obtain an integrity check on the key data. In the final step of the unwrapping process, the recovered value of A[0] is compared to the expected

value of A[0]. If there is a match, the key is accepted as valid, and the unwrapping algorithm returns it. If there is not a match, then the key is rejected, and the unwrapping algorithm returns an error.

The exact properties achieved by this integrity check depend on the definition of the initial value. Different applications may call for somewhat different properties; for example, whether there is need to determine the integrity of key data throughout its lifecycle or just when it is unwrapped. This specification defines a default initial value that supports integrity of the key data during the period it is wrapped (2.2.3.1). Provision is also made to support alternative initial values (in 2.2.3.2).

2.2.3.1 Default Initial Value

The default initial value (IV) is defined to be the hexadecimal constant:

$$A[0] = IV = A6A6A6A6A6A6A6A6$$

The use of a constant as the IV supports a strong integrity check on the key data during the period that it is wrapped. If unwrapping produces $A[0] = A6A6A6A6A6A6A6A6$, then the chance that the key data is corrupt is 2^{-64} . If unwrapping produces A[0] any other value, then the unwrap must return an error and not return any key data.

2.2.3.2 Alternative Initial Values

When the key wrap is used as part of a larger key management protocol or system, the desired scope for data integrity may be more than just the key data or the desired duration for more than just the period that it is wrapped. Also, if the key data is not just an AES key, it may not always be a multiple of 64 bits. Alternative definitions of the initial value can be used to address such problems. NIST will define alternative initial values in future key management publications as needed. In order to accommodate a set of alternatives that may evolve over time, key wrap implementations that are not application-specific will require some flexibility in the way that the initial value is set and tested.

3. Object Identifiers

NIST has assigned the following object identifiers to identify the key wrap algorithm with the default initial value specified in 2.2.3.1. One object identifier is assigned for use with each of the KEK AES key sizes.

```

aes OBJECT IDENTIFIER ::= { joint-iso-itu-t(2) country(16)
    us(840) organization(1) gov(101) csor(3) nistAlgorithm(4) 1 }

id-aes128-wrap OBJECT IDENTIFIER ::= { aes 5 }
id-aes192-wrap OBJECT IDENTIFIER ::= { aes 25 }
id-aes256-wrap OBJECT IDENTIFIER ::= { aes 45 }

```

4. Test Vectors

The examples in this section were generated using the index-based implementation of the key wrap algorithm. The use of this approach allows a straightforward software implementation of the key wrap algorithm.

4.1 Wrap 128 bits of Key Data with a 128-bit KEK

```

Input:
KEK:      000102030405060708090A0B0C0D0E0F
Key Data: 00112233445566778899AABBCCDDEEFF

```

Wrap:

Step t	A	R1	R2
1			
In	A6A6A6A6A6A6A6A6	0011223344556677	8899AABBCCDDEEFF
Enc	F4740052E82A2251	74CE86FBD7B805E7	8899AABBCCDDEEFF
XorT	F4740052E82A2250	74CE86FBD7B805E7	8899AABBCCDDEEFF
2			
In	F4740052E82A2250	74CE86FBD7B805E7	8899AABBCCDDEEFF
Enc	06BA4EBDE7768D0B	74CE86FBD7B805E7	D132EE38147E76F8
XorT	06BA4EBDE7768D09	74CE86FBD7B805E7	D132EE38147E76F8
3			
In	06BA4EBDE7768D09	74CE86FBD7B805E7	D132EE38147E76F8
Enc	FC967627BE937208	FE6E8D679C5D3460	D132EE38147E76F8
XorT	FC967627BE93720B	FE6E8D679C5D3460	D132EE38147E76F8

4

In	FC967627BE93720B	FE6E8D679C5D3460	D132EE38147E76F8
Enc	5896EA9028EE203B	FE6E8D679C5D3460	07B2BD973E36A6FC
XorT	5896EA9028EE203F	FE6E8D679C5D3460	07B2BD973E36A6FC

5

In	5896EA9028EE203F	FE6E8D679C5D3460	07B2BD973E36A6FC
Enc	93AEA71B258D90C3	25F5A3ADC2195401	07B2BD973E36A6FC
XorT	93AEA71B258D90C6	25F5A3ADC2195401	07B2BD973E36A6FC

6

In	93AEA71B258D90C6	25F5A3ADC2195401	07B2BD973E36A6FC
Enc	E3EE986344D878F7	25F5A3ADC2195401	F14863BB1E9CA90A
XorT	E3EE986344D878F1	25F5A3ADC2195401	F14863BB1E9CA90A

7

In	E3EE986344D878F1	25F5A3ADC2195401	F14863BB1E9CA90A
Enc	2BFC21B2C20E4006	B556D35ED8CEF052	F14863BB1E9CA90A
XorT	2BFC21B2C20E4001	B556D35ED8CEF052	F14863BB1E9CA90A

8

In	2BFC21B2C20E4001	B556D35ED8CEF052	F14863BB1E9CA90A
Enc	4BE8CE99C0A43A7D	B556D35ED8CEF052	64BAE5818D0570BB
XorT	4BE8CE99C0A43A75	B556D35ED8CEF052	64BAE5818D0570BB

9

In	4BE8CE99C0A43A75	B556D35ED8CEF052	64BAE5818D0570BB
Enc	EBE1CE91067024F3	BE114B343EB00981	64BAE5818D0570BB
XorT	EBE1CE91067024FA	BE114B343EB00981	64BAE5818D0570BB

10

In	EBE1CE91067024FA	BE114B343EB00981	64BAE5818D0570BB
Enc	5A9C7B1F5B1C3B46	BE114B343EB00981	4FD3D2B7D74FBB42
XorT	5A9C7B1F5B1C3B4C	BE114B343EB00981	4FD3D2B7D74FBB42

11

In	5A9C7B1F5B1C3B4C	BE114B343EB00981	4FD3D2B7D74FBB42
Enc	93B71967EED41FFC	AEF34BD8FB5A7B82	4FD3D2B7D74FBB42
XorT	93B71967EED41FF7	AEF34BD8FB5A7B82	4FD3D2B7D74FBB42

12

In	93B71967EED41FF7	AEF34BD8FB5A7B82	4FD3D2B7D74FBB42
Enc	1FA68B0A8112B44B	AEF34BD8FB5A7B82	9D3E862371D2CFE5
XorT	1FA68B0A8112B447	AEF34BD8FB5A7B82	9D3E862371D2CFE5

Output:

Ciphertext: 1FA68B0A8112B447 AEF34BD8FB5A7B82 9D3E862371D2CFE5

Unwrap:

Step t	A	R1	R2
12			
In	1FA68B0A8112B447	AEF34BD8FB5A7B82	9D3E862371D2CFE5
XorT	1FA68B0A8112B44B	AEF34BD8FB5A7B82	9D3E862371D2CFE5
Dec	93B71967EED41FF7	AEF34BD8FB5A7B82	4FD3D2B7D74FBB42
11			
In	93B71967EED41FF7	AEF34BD8FB5A7B82	4FD3D2B7D74FBB42
XorT	93B71967EED41FFC	AEF34BD8FB5A7B82	4FD3D2B7D74FBB42
Dec	5A9C7B1F5B1C3B4C	BE114B343EB00981	4FD3D2B7D74FBB42
10			
In	5A9C7B1F5B1C3B4C	BE114B343EB00981	4FD3D2B7D74FBB42
XorT	5A9C7B1F5B1C3B46	BE114B343EB00981	4FD3D2B7D74FBB42
Dec	EBE1CE91067024FA	BE114B343EB00981	64BAE5818D0570BB
9			
In	EBE1CE91067024FA	BE114B343EB00981	64BAE5818D0570BB
XorT	EBE1CE91067024F3	BE114B343EB00981	64BAE5818D0570BB
Dec	4BE8CE99C0A43A75	B556D35ED8CEF052	64BAE5818D0570BB
8			
In	4BE8CE99C0A43A75	B556D35ED8CEF052	64BAE5818D0570BB
XorT	4BE8CE99C0A43A7D	B556D35ED8CEF052	64BAE5818D0570BB
Dec	2BFC21B2C20E4001	B556D35ED8CEF052	F14863BB1E9CA90A
7			
In	2BFC21B2C20E4001	B556D35ED8CEF052	F14863BB1E9CA90A
XorT	2BFC21B2C20E4006	B556D35ED8CEF052	F14863BB1E9CA90A
Dec	E3EE986344D878F1	25F5A3ADC2195401	F14863BB1E9CA90A
6			
In	E3EE986344D878F1	25F5A3ADC2195401	F14863BB1E9CA90A
XorT	E3EE986344D878F7	25F5A3ADC2195401	F14863BB1E9CA90A
Dec	93AEA71B258D90C6	25F5A3ADC2195401	07B2BD973E36A6FC
5			
In	93AEA71B258D90C6	25F5A3ADC2195401	07B2BD973E36A6FC
XorT	93AEA71B258D90C3	25F5A3ADC2195401	07B2BD973E36A6FC
Dec	5896EA9028EE203F	FE6E8D679C5D3460	07B2BD973E36A6FC
4			
In	5896EA9028EE203F	FE6E8D679C5D3460	07B2BD973E36A6FC
XorT	5896EA9028EE203B	FE6E8D679C5D3460	07B2BD973E36A6FC
Dec	FC967627BE93720B	FE6E8D679C5D3460	D132EE38147E76F8

3

```
In    FC967627BE93720B FE6E8D679C5D3460 D132EE38147E76F8
XorT  FC967627BE937208 FE6E8D679C5D3460 D132EE38147E76F8
Dec   06BA4EBDE7768D09 74CE86FBD7B805E7 D132EE38147E76F8
```

2

```
In    06BA4EBDE7768D09 74CE86FBD7B805E7 D132EE38147E76F8
XorT  06BA4EBDE7768D0B 74CE86FBD7B805E7 D132EE38147E76F8
Dec   F4740052E82A2250 74CE86FBD7B805E7 8899AABBCCDDEEFF
```

1

```
In    F4740052E82A2250 74CE86FBD7B805E7 8899AABBCCDDEEFF
XorT  F4740052E82A2251 74CE86FBD7B805E7 8899AABBCCDDEEFF
Dec   A6A6A6A6A6A6A6A6 0011223344556677 8899AABBCCDDEEFF
```

Plaintext A6A6A6A6A6A6A6A6 0011223344556677 8899AABBCCDDEEFF

Output:

Key Data: 00112233445566778899AABBCCDDEEFF

4.2 Wrap 128 bits of Key Data with a 192-bit KEK

Input:

```
KEK:      000102030405060708090A0B0C0D0E0F1011121314151617
Key Data: 00112233445566778899AABBCCDDEEFF
```

Wrap:

Step t	A	R1	R21
In	A6A6A6A6A6A6A6A6	0011223344556677	8899AABBCCDDEEFF
Enc	DFE8FD5D1A3786A7	351D385096CCFB29	8899AABBCCDDEEFF
XorT	DFE8FD5D1A3786A6	351D385096CCFB29	8899AABBCCDDEEFF

2

In	DFE8FD5D1A3786A6	351D385096CCFB29	8899AABBCCDDEEFF
Enc	9D9B32B9ED742E02	351D385096CCFB29	51F22F3286758A2D
XorT	9D9B32B9ED742E00	351D385096CCFB29	51F22F3286758A2D

3

In	9D9B32B9ED742E00	351D385096CCFB29	51F22F3286758A2D
Enc	7B8E343CA51CF8AB	BC164F51E20CC983	51F22F3286758A2D
XorT	7B8E343CA51CF8A8	BC164F51E20CC983	51F22F3286758A2D

4

In	7B8E343CA51CF8A8	BC164F51E20CC983	51F22F3286758A2D
Enc	02A97C5897140595	BC164F51E20CC983	05FC2D8F8FF4B919
XorT	02A97C5897140591	BC164F51E20CC983	05FC2D8F8FF4B919

5

In	02A97C5897140591	BC164F51E20CC983	05FC2D8F8FF4B919
Enc	15D4B63F66583817	429487269D3A0016	05FC2D8F8FF4B919
XorT	15D4B63F66583812	429487269D3A0016	05FC2D8F8FF4B919

6

In	15D4B63F66583812	429487269D3A0016	05FC2D8F8FF4B919
Enc	AE2D0B76A6951EEA	429487269D3A0016	05A2D8FB4DD5BD7A
XorT	AE2D0B76A6951EEC	429487269D3A0016	05A2D8FB4DD5BD7A

7

In	AE2D0B76A6951EEC	429487269D3A0016	05A2D8FB4DD5BD7A
Enc	79F849444F4B8AA8	D40B091CDBAC0340	05A2D8FB4DD5BD7A
XorT	79F849444F4B8AAF	D40B091CDBAC0340	05A2D8FB4DD5BD7A

8

In	79F849444F4B8AAF	D40B091CDBAC0340	05A2D8FB4DD5BD7A
Enc	5933A9195B5F5E21	D40B091CDBAC0340	89F0D6C06F8CA9B4
XorT	5933A9195B5F5E29	D40B091CDBAC0340	89F0D6C06F8CA9B4

9

In	5933A9195B5F5E29	D40B091CDBAC0340	89F0D6C06F8CA9B4
Enc	57ADA800299C2E85	4D5B3DFE7C04ABBA	89F0D6C06F8CA9B4
XorT	57ADA800299C2E8C	4D5B3DFE7C04ABBA	89F0D6C06F8CA9B4

10

In	57ADA800299C2E8C	4D5B3DFE7C04ABBA	89F0D6C06F8CA9B4
Enc	BF17BD6A9BC80163	4D5B3DFE7C04ABBA	EB24CCFA52EA9078
XorT	BF17BD6A9BC80169	4D5B3DFE7C04ABBA	EB24CCFA52EA9078

11

In	BF17BD6A9BC80169	4D5B3DFE7C04ABBA	EB24CCFA52EA9078
Enc	B68BF270AE81544F	F92B5B97C050AED2	EB24CCFA52EA9078
XorT	B68BF270AE815444	F92B5B97C050AED2	EB24CCFA52EA9078

12

In	B68BF270AE815444	F92B5B97C050AED2	EB24CCFA52EA9078
Enc	96778B25AE6CA439	F92B5B97C050AED2	468AB8A17AD84E5D
XorT	96778B25AE6CA435	F92B5B97C050AED2	468AB8A17AD84E5D

Output:

Ciphertext: 96778B25AE6CA435 F92B5B97C050AED2 468AB8A17AD84E5D

Unwrap:

Step t	A	R1	R2
12			
In	96778B25AE6CA435	F92B5B97C050AED2	468AB8A17AD84E5D
XorT	96778B25AE6CA439	F92B5B97C050AED2	468AB8A17AD84E5D
Dec	B68BF270AE815444	F92B5B97C050AED2	EB24CCFA52EA9078
11			
In	B68BF270AE815444	F92B5B97C050AED2	EB24CCFA52EA9078
XorT	B68BF270AE81544F	F92B5B97C050AED2	EB24CCFA52EA9078
Dec	BF17BD6A9BC80169	4D5B3DFE7C04ABBA	EB24CCFA52EA9078
10			
In	BF17BD6A9BC80169	4D5B3DFE7C04ABBA	EB24CCFA52EA9078
XorT	BF17BD6A9BC80163	4D5B3DFE7C04ABBA	EB24CCFA52EA9078
Dec	57ADA800299C2E8C	4D5B3DFE7C04ABBA	89F0D6C06F8CA9B4
9			
In	57ADA800299C2E8C	4D5B3DFE7C04ABBA	89F0D6C06F8CA9B4
XorT	57ADA800299C2E85	4D5B3DFE7C04ABBA	89F0D6C06F8CA9B4
Dec	5933A9195B5F5E29	D40B091CDBAC0340	89F0D6C06F8CA9B4
8			
In	5933A9195B5F5E29	D40B091CDBAC0340	89F0D6C06F8CA9B4
XorT	5933A9195B5F5E21	D40B091CDBAC0340	89F0D6C06F8CA9B4
Dec	79F849444F4B8AAF	D40B091CDBAC0340	05A2D8FB4DD5BD7A
7			
In	79F849444F4B8AAF	D40B091CDBAC0340	05A2D8FB4DD5BD7A
XorT	79F849444F4B8AA8	D40B091CDBAC0340	05A2D8FB4DD5BD7A
Dec	AE2D0B76A6951EEC	429487269D3A0016	05A2D8FB4DD5BD7A
6			
In	AE2D0B76A6951EEC	429487269D3A0016	05A2D8FB4DD5BD7A
XorT	AE2D0B76A6951EEA	429487269D3A0016	05A2D8FB4DD5BD7A
Dec	15D4B63F66583812	429487269D3A0016	05FC2D8F8FF4B919
5			
In	15D4B63F66583812	429487269D3A0016	05FC2D8F8FF4B919
XorT	15D4B63F66583817	429487269D3A0016	05FC2D8F8FF4B919
Dec	02A97C5897140591	BC164F51E20CC983	05FC2D8F8FF4B919
4			
In	02A97C5897140591	BC164F51E20CC983	05FC2D8F8FF4B919
XorT	02A97C5897140595	BC164F51E20CC983	05FC2D8F8FF4B919
Dec	7B8E343CA51CF8A8	BC164F51E20CC983	51F22F3286758A2D

3

```
In    7B8E343CA51CF8A8 BC164F51E20CC983 51F22F3286758A2D
XorT  7B8E343CA51CF8AB BC164F51E20CC983 51F22F3286758A2D
Dec    9D9B32B9ED742E00 351D385096CCFB29 51F22F3286758A2D
```

2

```
In    9D9B32B9ED742E00 351D385096CCFB29 51F22F3286758A2D
XorT  9D9B32B9ED742E02 351D385096CCFB29 51F22F3286758A2D
Dec    DFE8FD5D1A3786A6 351D385096CCFB29 8899AABBCCDDEEFF
```

1

```
In    DFE8FD5D1A3786A6 351D385096CCFB29 8899AABBCCDDEEFF
XorT  DFE8FD5D1A3786A7 351D385096CCFB29 8899AABBCCDDEEFF
Dec    A6A6A6A6A6A6A6A6 0011223344556677 8899AABBCCDDEEFF
```

Plaintext A6A6A6A6A6A6A6A6 0011223344556677 8899AABBCCDDEEFF

Output:

Key Data: 00112233445566778899AABBCCDDEEFF

4.3 Wrap 128 bits of Key Data with a 256-bit KEK

Input:

KEK:000102030405060708090A0B0C0D0E0F101112131415161718191A1B1C1D1E1F

Key Data: 00112233445566778899AABBCCDDEEFF

Wrap:

Step t	A	R1	R2
1			
In	A6A6A6A6A6A6A6A6	0011223344556677	8899AABBCCDDEEFF
Enc	794314D454E3FDE1	F661BD9F31FBFA31	8899AABBCCDDEEFF
XorT	794314D454E3FDE0	F661BD9F31FBFA31	8899AABBCCDDEEFF
2			
In	794314D454E3FDE0	F661BD9F31FBFA31	8899AABBCCDDEEFF
Enc	D450EA5C5BBCB561	F661BD9F31FBFA31	F60E0CDB7F429FE8
XorT	D450EA5C5BBCB563	F661BD9F31FBFA31	F60E0CDB7F429FE8
3			
In	D450EA5C5BBCB563	F661BD9F31FBFA31	F60E0CDB7F429FE8
Enc	85DBDF1879D5C0A5	5602001BFA07AD8B	F60E0CDB7F429FE8
XorT	85DBDF1879D5C0A6	5602001BFA07AD8B	F60E0CDB7F429FE8

4

In	85DBDF1879D5C0A6	5602001BFA07AD8B	F60E0CDB7F429FE8
Enc	738C291128B7226D	5602001BFA07AD8B	58924F777C3F678C
XorT	738C291128B72269	5602001BFA07AD8B	58924F777C3F678C

5

In	738C291128B72269	5602001BFA07AD8B	58924F777C3F678C
Enc	2656A02DFFF054DC	F4DF378183E3D5B2	58924F777C3F678C
XorT	2656A02DFFF054D9	F4DF378183E3D5B2	58924F777C3F678C

6

In	2656A02DFFF054D9	F4DF378183E3D5B2	58924F777C3F678C
Enc	DDFD0C0E8B52A63A	F4DF378183E3D5B2	91AC1D36A964F41B
XorT	DDFD0C0E8B52A63C	F4DF378183E3D5B2	91AC1D36A964F41B

7

In	DDFD0C0E8B52A63C	F4DF378183E3D5B2	91AC1D36A964F41B
Enc	39AB00D4AE4399EA	5271D5CED80F34ED	91AC1D36A964F41B
XorT	39AB00D4AE4399ED	5271D5CED80F34ED	91AC1D36A964F41B

8

In	39AB00D4AE4399ED	5271D5CED80F34ED	91AC1D36A964F41B
Enc	4CE414878463EAA4	5271D5CED80F34ED	67D8ED899E7929B8
XorT	4CE414878463EAA4	5271D5CED80F34ED	67D8ED899E7929B8

9

In	4CE414878463EAA4	5271D5CED80F34ED	67D8ED899E7929B8
Enc	FBB44DB106AA0789	0DF7E50829123648	67D8ED899E7929B8
XorT	FBB44DB106AA0780	0DF7E50829123648	67D8ED899E7929B8

10

In	FBB44DB106AA0780	0DF7E50829123648	67D8ED899E7929B8
Enc	877112A7308ADCC5	0DF7E50829123648	3472D5993D318FD2
XorT	877112A7308ADCCF	0DF7E50829123648	3472D5993D318FD2

11

In	877112A7308ADCCF	0DF7E50829123648	3472D5993D318FD2
Enc	78E40190807CC151	63E9777905818A2A	3472D5993D318FD2
XorT	78E40190807CC15A	63E9777905818A2A	3472D5993D318FD2

12

In	78E40190807CC15A	63E9777905818A2A	3472D5993D318FD2
Enc	64E8C3F9CE0F5BAE	63E9777905818A2A	93C8191E7D6E8AE7
XorT	64E8C3F9CE0F5BA2	63E9777905818A2A	93C8191E7D6E8AE7

Output:

Ciphertext: 64E8C3F9CE0F5BA2 63E9777905818A2A 93C8191E7D6E8AE7

Unwrap:

Step t	A	R1	R2
12			
In	64E8C3F9CE0F5BA2	63E9777905818A2A	93C8191E7D6E8AE7
XorT	64E8C3F9CE0F5BAE	63E9777905818A2A	93C8191E7D6E8AE7
Dec	78E40190807CC15A	63E9777905818A2A	3472D5993D318FD2
11			
In	78E40190807CC15A	63E9777905818A2A	3472D5993D318FD2
XorT	78E40190807CC151	63E9777905818A2A	3472D5993D318FD2
Dec	877112A7308ADCCF	0DF7E50829123648	3472D5993D318FD2
10			
In	877112A7308ADCCF	0DF7E50829123648	3472D5993D318FD2
XorT	877112A7308ADCC5	0DF7E50829123648	3472D5993D318FD2
Dec	FBB44DB106AA0780	0DF7E50829123648	67D8ED899E7929B8
9			
In	FBB44DB106AA0780	0DF7E50829123648	67D8ED899E7929B8
XorT	FBB44DB106AA0789	0DF7E50829123648	67D8ED899E7929B8
Dec	4CE414878463EAA4	5271D5CED80F34ED	67D8ED899E7929B8
8			
In	4CE414878463EAA4	5271D5CED80F34ED	67D8ED899E7929B8
XorT	4CE414878463EAA4	5271D5CED80F34ED	67D8ED899E7929B8
Dec	39AB00D4AE4399ED	5271D5CED80F34ED	91AC1D36A964F41B
7			
In	39AB00D4AE4399ED	5271D5CED80F34ED	91AC1D36A964F41B
XorT	39AB00D4AE4399EA	5271D5CED80F34ED	91AC1D36A964F41B
Dec	DDFD0C0E8B52A63C	F4DF378183E3D5B2	91AC1D36A964F41B
6			
In	DDFD0C0E8B52A63C	F4DF378183E3D5B2	91AC1D36A964F41B
XorT	DDFD0C0E8B52A63A	F4DF378183E3D5B2	91AC1D36A964F41B
Dec	2656A02DFFF054D9	F4DF378183E3D5B2	58924F777C3F678C
5			
In	2656A02DFFF054D9	F4DF378183E3D5B2	58924F777C3F678C
XorT	2656A02DFFF054DC	F4DF378183E3D5B2	58924F777C3F678C
Dec	738C291128B72269	5602001BFA07AD8B	58924F777C3F678C
4			
In	738C291128B72269	5602001BFA07AD8B	58924F777C3F678C
XorT	738C291128B7226D	5602001BFA07AD8B	58924F777C3F678C
Dec	85DBDF1879D5C0A6	5602001BFA07AD8B	F60E0CDB7F429FE8

3

```
In    85DBDF1879D5C0A6 5602001BFA07AD8B F60E0CDB7F429FE8
XorT 85DBDF1879D5C0A5 5602001BFA07AD8B F60E0CDB7F429FE8
Dec   D450EA5C5BBCB563 F661BD9F31FBFA31 F60E0CDB7F429FE8
```

2

```
In    D450EA5C5BBCB563 F661BD9F31FBFA31 F60E0CDB7F429FE8
XorT  D450EA5C5BBCB561 F661BD9F31FBFA31 F60E0CDB7F429FE8
Dec   794314D454E3FDE0 F661BD9F31FBFA31 8899AABBCCDDEEFF
```

1

```
In    794314D454E3FDE0 F661BD9F31FBFA31 8899AABBCCDDEEFF
XorT  794314D454E3FDE1 F661BD9F31FBFA31 8899AABBCCDDEEFF
Dec   A6A6A6A6A6A6A6A6 0011223344556677 8899AABBCCDDEEFF
```

Plaintext A6A6A6A6A6A6A6A6 0011223344556677 8899AABBCCDDEEFF

Output:

Key Data: 00112233445566778899AABBCCDDEEFF

4.4 Wrap 192 bits of Key Data with a 192-bit KEK

Input:

```
KEK:      000102030405060708090A0B0C0D0E0F1011121314151617
Key Data: 00112233445566778899AABBCCDDEEFF0001020304050607
```

Wrap:

Step t	A/R3	R1	R2
1			
In	A6A6A6A6A6A6A6A6 0001020304050607	0011223344556677	8899AABBCCDDEEFF
Enc	DFE8FD5D1A3786A7 0001020304050607	351D385096CCFB29	8899AABBCCDDEEFF
XorT	DFE8FD5D1A3786A6 0001020304050607	351D385096CCFB29	8899AABBCCDDEEFF
2			
In	DFE8FD5D1A3786A6 0001020304050607	351D385096CCFB29	8899AABBCCDDEEFF
Enc	9D9B32B9ED742E02 0001020304050607	351D385096CCFB29	51F22F3286758A2D
XorT	9D9B32B9ED742E00 0001020304050607	351D385096CCFB29	51F22F3286758A2D

3

In	9D9B32B9ED742E00 0001020304050607	351D385096CCFB29	51F22F3286758A2D
Enc	2C8E19A519025B7C FF540E514DE120A3	351D385096CCFB29	51F22F3286758A2D
XorT	2C8E19A519025B7F FF540E514DE120A3	351D385096CCFB29	51F22F3286758A2D

4

In	2C8E19A519025B7F FF540E514DE120A3	351D385096CCFB29	51F22F3286758A2D
Enc	E727C7BDF822602E FF540E514DE120A3	A08DAA041D17BBBA	51F22F3286758A2D
XorT	E727C7BDF822602A FF540E514DE120A3	A08DAA041D17BBBA	51F22F3286758A2D

5

In	E727C7BDF822602A FF540E514DE120A3	A08DAA041D17BBBA	51F22F3286758A2D
Enc	15B61F7B25D51700 FF540E514DE120A3	A08DAA041D17BBBA	AE82BC1118A5DEA4
XorT	15B61F7B25D51705 FF540E514DE120A3	A08DAA041D17BBBA	AE82BC1118A5DEA4

6

In	15B61F7B25D51705 FF540E514DE120A3	A08DAA041D17BBBA	AE82BC1118A5DEA4
Enc	A187755AEA64719C D1E708FD13778787	A08DAA041D17BBBA	AE82BC1118A5DEA4
XorT	A187755AEA64719A D1E708FD13778787	A08DAA041D17BBBA	AE82BC1118A5DEA4

7

In	A187755AEA64719A D1E708FD13778787	A08DAA041D17BBBA	AE82BC1118A5DEA4
Enc	5A994895D81644B7 D1E708FD13778787	926ED65A9E853FD9	AE82BC1118A5DEA4
XorT	5A994895D81644B0 D1E708FD13778787	926ED65A9E853FD9	AE82BC1118A5DEA4

8

In	5A994895D81644B0 D1E708FD13778787	926ED65A9E853FD9	AE82BC1118A5DEA4
Enc	864F408C8AB8CDCF D1E708FD13778787	926ED65A9E853FD9	552A09E141D08AE3
XorT	864F408C8AB8CDC7 D1E708FD13778787	926ED65A9E853FD9	552A09E141D08AE3

9

In	864F408C8AB8CDC7 D1E708FD13778787	926ED65A9E853FD9	552A09E141D08AE3
Enc	53F4373F575EB7A4 ED5E8456E61BD295	926ED65A9E853FD9	552A09E141D08AE3
XorT	53F4373F575EB7AD ED5E8456E61BD295	926ED65A9E853FD9	552A09E141D08AE3

10

In	53F4373F575EB7AD ED5E8456E61BD295	926ED65A9E853FD9	552A09E141D08AE3
Enc	9EAA4CDA0B1BA5FF ED5E8456E61BD295	98883EDC6B080FB5	552A09E141D08AE3
XorT	9EAA4CDA0B1BA5F5 ED5E8456E61BD295	98883EDC6B080FB5	552A09E141D08AE3

11

In	9EAA4CDA0B1BA5F5 ED5E8456E61BD295	98883EDC6B080FB5	552A09E141D08AE3
Enc	B1B9902C68E0EB52 ED5E8456E61BD295	98883EDC6B080FB5	63F6D88A0663FEF9
XorT	B1B9902C68E0EB59 ED5E8456E61BD295	98883EDC6B080FB5	63F6D88A0663FEF9

12

In	B1B9902C68E0EB59 ED5E8456E61BD295	98883EDC6B080FB5	63F6D88A0663FEF9
Enc	FCE591D77709A6E0 463437433A93EFE5	98883EDC6B080FB5	63F6D88A0663FEF9
XorT	FCE591D77709A6EC 463437433A93EFE5	98883EDC6B080FB5	63F6D88A0663FEF9

13

In	FCE591D77709A6EC 463437433A93EFE5	98883EDC6B080FB5	63F6D88A0663FEF9
Enc	428428D2BD88CF58 463437433A93EFE5	C46965F34EFB2261	63F6D88A0663FEF9
XorT	428428D2BD88CF55 463437433A93EFE5	C46965F34EFB2261	63F6D88A0663FEF9

14

In	428428D2BD88CF55 463437433A93EFE5	C46965F34EFB2261	63F6D88A0663FEF9
Enc	6AC861AB961DA578 463437433A93EFE5	C46965F34EFB2261	56E3CEE892BBEFC4
XorT	6AC861AB961DA576 463437433A93EFE5	C46965F34EFB2261	56E3CEE892BBEFC4

15

```

In      6AC861AB961DA576 C46965F34EFB2261 56E3CEE892BBEFC4
        463437433A93EFE5
Enc     E80DB49CC9A1EA61 C46965F34EFB2261 56E3CEE892BBEFC4
        84943C8C67FCFD53
XorT   E80DB49CC9A1EA6E C46965F34EFB2261 56E3CEE892BBEFC4
        84943C8C67FCFD53

```

16

```

In      E80DB49CC9A1EA6E C46965F34EFB2261 56E3CEE892BBEFC4
        84943C8C67FCFD53
Enc     ABEE3534AC465C2C 68F24EC260743EDC 56E3CEE892BBEFC4
        84943C8C67FCFD53
XorT   ABEE3534AC465C3C 68F24EC260743EDC 56E3CEE892BBEFC4
        84943C8C67FCFD53

```

17

```

In      ABEE3534AC465C3C 68F24EC260743EDC 56E3CEE892BBEFC4
        84943C8C67FCFD53
Enc     E7CC8D8CEDE62BF7 68F24EC260743EDC E1C6C7DDEE725A93
        84943C8C67FCFD53
XorT   E7CC8D8CEDE62BE6 68F24EC260743EDC E1C6C7DDEE725A93
        84943C8C67FCFD53

```

18

```

In      E7CC8D8CEDE62BE6 68F24EC260743EDC E1C6C7DDEE725A93
        84943C8C67FCFD53
Enc     031D33264E15D320 68F24EC260743EDC E1C6C7DDEE725A93
        6BA814915C6762D2
XorT   031D33264E15D332 68F24EC260743EDC E1C6C7DDEE725A93
        6BA814915C6762D2

```

Output:

```

Ciphertext  031D33264E15D332 68F24EC260743EDC E1C6C7DDEE725A93
            6BA814915C6762D2

```

Unwrap:

Step	t	A/R3	R1	R2
18				
In		031D33264E15D332	68F24EC260743EDC	E1C6C7DDEE725A93
		6BA814915C6762D2		
XorT		031D33264E15D320	68F24EC260743EDC	E1C6C7DDEE725A93
		6BA814915C6762D2		
Dec		E7CC8D8CEDE62BE6	68F24EC260743EDC	E1C6C7DDEE725A93
		84943C8C67FCFD53		

```

17
In    E7CC8D8CEDE62BE6 68F24EC260743EDC E1C6C7DDEE725A93
      84943C8C67FCFD53
XorT  E7CC8D8CEDE62BF7 68F24EC260743EDC E1C6C7DDEE725A93
      84943C8C67FCFD53
Dec   ABEE3534AC465C3C 68F24EC260743EDC 56E3CEE892BBEFC4
      84943C8C67FCFD53

16
In    ABEE3534AC465C3C 68F24EC260743EDC 56E3CEE892BBEFC4
      84943C8C67FCFD53
XorT  ABEE3534AC465C2C 68F24EC260743EDC 56E3CEE892BBEFC4
      84943C8C67FCFD53
Dec   E80DB49CC9A1EA6E C46965F34EFB2261 56E3CEE892BBEFC4
      84943C8C67FCFD53

15
In    E80DB49CC9A1EA6E C46965F34EFB2261 56E3CEE892BBEFC4
      84943C8C67FCFD53
XorT  E80DB49CC9A1EA61 C46965F34EFB2261 56E3CEE892BBEFC4
      84943C8C67FCFD53
Dec   6AC861AB961DA576 C46965F34EFB2261 56E3CEE892BBEFC4
      463437433A93EFE5

14
In    6AC861AB961DA576 C46965F34EFB2261 56E3CEE892BBEFC4
      463437433A93EFE5
XorT  6AC861AB961DA578 C46965F34EFB2261 56E3CEE892BBEFC4
      463437433A93EFE5
Dec   428428D2BD88CF55 C46965F34EFB2261 63F6D88A0663FEF9
      463437433A93EFE5

13
In    428428D2BD88CF55 C46965F34EFB2261 63F6D88A0663FEF9
      463437433A93EFE5
XorT  428428D2BD88CF58 C46965F34EFB2261 63F6D88A0663FEF9
      463437433A93EFE5
Dec   FCE591D77709A6EC 98883EDC6B080FB5 63F6D88A0663FEF9
      463437433A93EFE5

12
In    FCE591D77709A6EC 98883EDC6B080FB5 63F6D88A0663FEF9
      463437433A93EFE5
XorT  FCE591D77709A6E0 98883EDC6B080FB5 63F6D88A0663FEF9
      463437433A93EFE5
Dec   B1B9902C68E0EB59 98883EDC6B080FB5 63F6D88A0663FEF9
      ED5E8456E61BD295

```

11
In B1B9902C68E0EB59 98883EDC6B080FB5 63F6D88A0663FEF9
ED5E8456E61BD295
XorT B1B9902C68E0EB52 98883EDC6B080FB5 63F6D88A0663FEF9
ED5E8456E61BD295
Dec 9EAA4CDA0B1BA5F5 98883EDC6B080FB5 552A09E141D08AE3
ED5E8456E61BD295

10
In 9EAA4CDA0B1BA5F5 98883EDC6B080FB5 552A09E141D08AE3
ED5E8456E61BD295
XorT 9EAA4CDA0B1BA5FF 98883EDC6B080FB5 552A09E141D08AE3
ED5E8456E61BD295
Dec 53F4373F575EB7AD 926ED65A9E853FD9 552A09E141D08AE3
ED5E8456E61BD295

9
In 53F4373F575EB7AD 926ED65A9E853FD9 552A09E141D08AE3
ED5E8456E61BD295
XorT 53F4373F575EB7A4 926ED65A9E853FD9 552A09E141D08AE3
ED5E8456E61BD295
Dec 864F408C8AB8CDC7 926ED65A9E853FD9 552A09E141D08AE3
D1E708FD13778787

8
In 864F408C8AB8CDC7 926ED65A9E853FD9 552A09E141D08AE3
D1E708FD13778787
XorT 864F408C8AB8CDCF 926ED65A9E853FD9 552A09E141D08AE3
D1E708FD13778787
Dec 5A994895D81644B0 926ED65A9E853FD9 AE82BC1118A5DEA4
D1E708FD13778787

7
In 5A994895D81644B0 926ED65A9E853FD9 AE82BC1118A5DEA4
D1E708FD13778787
XorT 5A994895D81644B7 926ED65A9E853FD9 AE82BC1118A5DEA4
D1E708FD13778787
Dec A187755AEA64719A A08DAA041D17BBBA AE82BC1118A5DEA4
D1E708FD13778787

6
In A187755AEA64719A A08DAA041D17BBBA AE82BC1118A5DEA4
D1E708FD13778787
XorT A187755AEA64719C A08DAA041D17BBBA AE82BC1118A5DEA4
D1E708FD13778787
Dec 15B61F7B25D51705 A08DAA041D17BBBA AE82BC1118A5DEA4
FF540E514DE120A3

5

```

In    15B61F7B25D51705 A08DAA041D17BBBA AE82BC1118A5DEA4
      FF540E514DE120A3
XorT  15B61F7B25D51700 A08DAA041D17BBBA AE82BC1118A5DEA4
      FF540E514DE120A3
Dec   E727C7BDF822602A A08DAA041D17BBBA 51F22F3286758A2D
      FF540E514DE120A3

```

4

```

In    E727C7BDF822602A A08DAA041D17BBBA 51F22F3286758A2D
      FF540E514DE120A3
XorT  E727C7BDF822602E A08DAA041D17BBBA 51F22F3286758A2D
      FF540E514DE120A3
Dec   2C8E19A519025B7F 351D385096CCFB29 51F22F3286758A2D
      FF540E514DE120A3

```

3

```

In    2C8E19A519025B7F 351D385096CCFB29 51F22F3286758A2D
      FF540E514DE120A3
XorT  2C8E19A519025B7C 351D385096CCFB29 51F22F3286758A2D
      FF540E514DE120A3
Dec   9D9B32B9ED742E00 351D385096CCFB29 51F22F3286758A2D
      0001020304050607

```

2

```

In    9D9B32B9ED742E00 351D385096CCFB29 51F22F3286758A2D
      0001020304050607
XorT  9D9B32B9ED742E02 351D385096CCFB29 51F22F3286758A2D
      0001020304050607
Dec   DFE8FD5D1A3786A6 351D385096CCFB29 8899AABBCCDDEEFF
      0001020304050607

```

1

```

In    DFE8FD5D1A3786A6 351D385096CCFB29 8899AABBCCDDEEFF
      0001020304050607
XorT  DFE8FD5D1A3786A7 351D385096CCFB29 8899AABBCCDDEEFF
      0001020304050607
Dec   A6A6A6A6A6A6A6A6 0011223344556677 8899AABBCCDDEEFF
      0001020304050607

```

```

Plaintext  A6A6A6A6A6A6A6A6 0011223344556677
            8899AABBCCDDEEFF 0001020304050607

```

Output:

```

Key Data:  00112233445566778899AABBCCDDEEFF0001020304050607

```

4.5 Wrap 192 bits of Key Data with a 256-bit KEK

Input:

KEK:

000102030405060708090A0B0C0D0E0F101112131415161718191A1B1C1D1E1F

Key Data: 00112233445566778899AABBCCDDEEFF0001020304050607

Wrap:

Step	t	A/R3	R1	R2
1				
In		A6A6A6A6A6A6A6A6 0001020304050607	0011223344556677	8899AABBCCDDEEFF
Enc		794314D454E3FDE1 0001020304050607	F661BD9F31FBFA31	8899AABBCCDDEEFF
XorT		794314D454E3FDE0 0001020304050607	F661BD9F31FBFA31	8899AABBCCDDEEFF
2				
In		794314D454E3FDE0 0001020304050607	F661BD9F31FBFA31	8899AABBCCDDEEFF
Enc		D450EA5C5BBCB561 0001020304050607	F661BD9F31FBFA31	F60E0CDB7F429FE8
XorT		D450EA5C5BBCB563 0001020304050607	F661BD9F31FBFA31	F60E0CDB7F429FE8
3				
In		D450EA5C5BBCB563 0001020304050607	F661BD9F31FBFA31	F60E0CDB7F429FE8
Enc		9DF8F5405FBC00C1 6CA405593A3B5154	F661BD9F31FBFA31	F60E0CDB7F429FE8
XorT		9DF8F5405FBC00C2 6CA405593A3B5154	F661BD9F31FBFA31	F60E0CDB7F429FE8
4				
In		9DF8F5405FBC00C2 6CA405593A3B5154	F661BD9F31FBFA31	F60E0CDB7F429FE8
Enc		F1D28EA6295891EC 6CA405593A3B5154	0CC86A4D9B9C6A31	F60E0CDB7F429FE8
XorT		F1D28EA6295891E8 6CA405593A3B5154	0CC86A4D9B9C6A31	F60E0CDB7F429FE8

5

```

In    F1D28EA6295891E8 0CC86A4D9B9C6A31 F60E0CDB7F429FE8
      6CA405593A3B5154
Enc   BF213BFD04E8A24F 0CC86A4D9B9C6A31 AEBE2D5C8BF747A9
      6CA405593A3B5154
XorT  BF213BFD04E8A24A 0CC86A4D9B9C6A31 AEBE2D5C8BF747A9
      6CA405593A3B5154

```

6

```

In    BF213BFD04E8A24A 0CC86A4D9B9C6A31 AEBE2D5C8BF747A9
      6CA405593A3B5154
Enc   6F85BFBDB7E880E3 0CC86A4D9B9C6A31 AEBE2D5C8BF747A9
      39EBC1A1A53FF55B
XorT  6F85BFBDB7E880E5 0CC86A4D9B9C6A31 AEBE2D5C8BF747A9
      39EBC1A1A53FF55B

```

7

```

In    6F85BFBDB7E880E5 0CC86A4D9B9C6A31 AEBE2D5C8BF747A9
      39EBC1A1A53FF55B
Enc   D532789E4E79D819 444F92BF78E77BB1 AEBE2D5C8BF747A9
      39EBC1A1A53FF55B
XorT  D532789E4E79D81E 444F92BF78E77BB1 AEBE2D5C8BF747A9
      39EBC1A1A53FF55B

```

8

```

In    D532789E4E79D81E 444F92BF78E77BB1 AEBE2D5C8BF747A9
      39EBC1A1A53FF55B
Enc   2A5FFCEF1F1916D8 444F92BF78E77BB1 C6874607903270CD
      39EBC1A1A53FF55B
XorT  2A5FFCEF1F1916D0 444F92BF78E77BB1 C6874607903270CD
      39EBC1A1A53FF55B

```

9

```

In    2A5FFCEF1F1916D0 444F92BF78E77BB1 C6874607903270CD
      39EBC1A1A53FF55B
Enc   01271BA91D9804F6 444F92BF78E77BB1 C6874607903270CD
      740A273461ED82C6
XorT  01271BA91D9804FF 444F92BF78E77BB1 C6874607903270CD
      740A273461ED82C6

```

10

```

In    01271BA91D9804FF 444F92BF78E77BB1 C6874607903270CD
      740A273461ED82C6
Enc   A3223BD7237F7033 FB1611A83BEB567F C6874607903270CD
      740A273461ED82C6
XorT  A3223BD7237F7039 FB1611A83BEB567F C6874607903270CD
      740A273461ED82C6

```

11
In A3223BD7237F7039 FB1611A83BEB567F C6874607903270CD
740A273461ED82C6
Enc B50C330616E7B1C7 FB1611A83BEB567F 73EDC8CB9322C34E
740A273461ED82C6
XorT B50C330616E7B1CC FB1611A83BEB567F 73EDC8CB9322C34E
740A273461ED82C6

12
In B50C330616E7B1CC FB1611A83BEB567F 73EDC8CB9322C34E
740A273461ED82C6
Enc FB8AFF3F083E12CE FB1611A83BEB567F 73EDC8CB9322C34E
0B08CFDF48020F0D
XorT FB8AFF3F083E12C2 FB1611A83BEB567F 73EDC8CB9322C34E
0B08CFDF48020F0D

13
In FB8AFF3F083E12C2 FB1611A83BEB567F 73EDC8CB9322C34E
0B08CFDF48020F0D
Enc 82F597607784A33C FB1F2965FCE1E783 73EDC8CB9322C34E
0B08CFDF48020F0D
XorT 82F597607784A331 FB1F2965FCE1E783 73EDC8CB9322C34E
0B08CFDF48020F0D

14
In 82F597607784A331 FB1F2965FCE1E783 73EDC8CB9322C34E
0B08CFDF48020F0D
Enc D48E5E83B7C906DB FB1F2965FCE1E783 D36F4FFBA2C82ED9
0B08CFDF48020F0D
XorT D48E5E83B7C906D5 FB1F2965FCE1E783 D36F4FFBA2C82ED9
0B08CFDF48020F0D

15
In D48E5E83B7C906D5 FB1F2965FCE1E783 D36F4FFBA2C82ED9
0B08CFDF48020F0D
Enc 1BF2B1CD947311B6 FB1F2965FCE1E783 D36F4FFBA2C82ED9
C490C33642717146
XorT 1BF2B1CD947311B9 FB1F2965FCE1E783 D36F4FFBA2C82ED9
C490C33642717146

16
In 1BF2B1CD947311B9 FB1F2965FCE1E783 D36F4FFBA2C82ED9
C490C33642717146
Enc C9F5F26A378011DE F6E6F4FBE30E71E4 D36F4FFBA2C82ED9
C490C33642717146
XorT C9F5F26A378011CE F6E6F4FBE30E71E4 D36F4FFBA2C82ED9
C490C33642717146

```

17
In    C9F5F26A378011CE F6E6F4FBE30E71E4 D36F4FFBA2C82ED9
      C490C33642717146
Enc   39128CE5E435F3A0 F6E6F4FBE30E71E4 769C8B80A32CB895
      C490C33642717146
XorT  39128CE5E4325F3B1 F6E6F4FBE30E71E4 769C8B80A32CB895
      C490C33642717146

```

```

18
In    39128CE5E435F3B1 F6E6F4FBE30E71E4 769C8B80A32CB895
      C490C33642717146
Enc   A8F9BC1612C68B2D F6E6F4FBE30E71E4 769C8B80A32CB895
      8CD5D17D6B254DA1
XorT  A8F9BC1612C68B3F F6E6F4FBE30E71E4 769C8B80A32CB895
      8CD5D17D6B254DA1

```

```

Ciphertext  A8F9BC1612C68B3F F6E6F4FBE30E71E4
              769C8B80A32CB895 8CD5D17D6B254DA1

```

Unwrap:

Step t	A/R3	R1	R2
18			
In	A8F9BC1612C68B3F 8CD5D17D6B254DA1	F6E6F4FBE30E71E4	769C8B80A32CB895
XorT	A8F9BC1612C68B2D 8CD5D17D6B254DA1	F6E6F4FBE30E71E4	769C8B80A32CB895
Dec	39128CE5E435F3B1 C490C33642717146	F6E6F4FBE30E71E4	769C8B80A32CB895
17			
In	39128CE5E435F3B1 C490C33642717146	F6E6F4FBE30E71E4	769C8B80A32CB895
XorT	39128CE5E435F3A0 C490C33642717146	F6E6F4FBE30E71E4	769C8B80A32CB895
Dec	C9F5F26A378011CE C490C33642717146	F6E6F4FBE30E71E4	D36F4FFBA2C82ED9
16			
In	C9F5F26A378011CE C490C33642717146	F6E6F4FBE30E71E4	D36F4FFBA2C82ED9
XorT	C9F5F26A378011DE C490C33642717146	F6E6F4FBE30E71E4	D36F4FFBA2C82ED9
Dec	1BF2B1CD947311B9 C490C33642717146	FB1F2965FCE1E783	D36F4FFBA2C82ED9

```

15
In    1BF2B1CD947311B9 FB1F2965FCE1E783 D36F4FFBA2C82ED9
      C490C33642717146
XorT  1BF2B1CD947311B6 FB1F2965FCE1E783 D36F4FFBA2C82ED9
      C490C33642717146
Dec   D48E5E83B7C906D5 FB1F2965FCE1E783 D36F4FFBA2C82ED9
      0B08CFDF48020F0D

14
In    D48E5E83B7C906D5 FB1F2965FCE1E783 D36F4FFBA2C82ED9
      0B08CFDF48020F0D
XorT  D48E5E83B7C906DB FB1F2965FCE1E783 D36F4FFBA2C82ED9
      0B08CFDF48020F0D
Dec   82F597607784A331 FB1F2965FCE1E783 73EDC8CB9322C34E
      0B08CFDF48020F0D

13
In    82F597607784A331 FB1F2965FCE1E783 73EDC8CB9322C34E
      0B08CFDF48020F0D
XorT  82F597607784A33C FB1F2965FCE1E783 73EDC8CB9322C34E
      0B08CFDF48020F0D
Dec   FB8AFF3F083E12C2 FB1611A83BEB567F 73EDC8CB9322C34E
      0B08CFDF48020F0D

12
In    FB8AFF3F083E12C2 FB1611A83BEB567F 73EDC8CB9322C34E
      0B08CFDF48020F0D
XorT  FB8AFF3F083E12CE FB1611A83BEB567F 73EDC8CB9322C34E
      0B08CFDF48020F0D
Dec   B50C330616E7B1CC FB1611A83BEB567F 73EDC8CB9322C34E
      740A273461ED82C6

11
In    B50C330616E7B1CC FB1611A83BEB567F 73EDC8CB9322C34E
      740A273461ED82C6
XorT  B50C330616E7B1C7 FB1611A83BEB567F 73EDC8CB9322C34E
      740A273461ED82C6
Dec   A3223BD7237F7039 FB1611A83BEB567F C6874607903270CD
      740A273461ED82C6

10
In    A3223BD7237F7039 FB1611A83BEB567F C6874607903270CD
      740A273461ED82C6
XorT  A3223BD7237F7033 FB1611A83BEB567F C6874607903270CD
      740A273461ED82C6
Dec   01271BA91D9804FF 444F92BF78E77BB1 C6874607903270CD
      740A273461ED82C6

```

```

9
In  01271BA91D9804FF 444F92BF78E77BB1 C6874607903270CD
    740A273461ED82C6
XorT 01271BA91D9804F6 444F92BF78E77BB1 C6874607903270CD
    740A273461ED82C6
Dec  2A5FFCEF1F1916D0 444F92BF78E77BB1 C6874607903270CD
    39EBC1A1A53FF55B

8
In  2A5FFCEF1F1916D0 444F92BF78E77BB1 C6874607903270CD
    39EBC1A1A53FF55B
XorT 2A5FFCEF1F1916D8 444F92BF78E77BB1 C6874607903270CD
    39EBC1A1A53FF55B
Dec  D532789E4E79D81E 444F92BF78E77BB1 AEBE2D5C8BF747A9
    39EBC1A1A53FF55B

7
In  D532789E4E79D81E 444F92BF78E77BB1 AEBE2D5C8BF747A9
    39EBC1A1A53FF55B
XorT D532789E4E79D819 444F92BF78E77BB1 AEBE2D5C8BF747A9
    39EBC1A1A53FF55B
Dec  6F85BFBDB7E880E5 0CC86A4D9B9C6A31 AEBE2D5C8BF747A9
    39EBC1A1A53FF55B

6
In  6F85BFBDB7E880E5 0CC86A4D9B9C6A31 AEBE2D5C8BF747A9
    39EBC1A1A53FF55B
XorT 6F85BFBDB7E880E3 0CC86A4D9B9C6A31 AEBE2D5C8BF747A9
    39EBC1A1A53FF55B
Dec  BF213BFD04E8A24A 0CC86A4D9B9C6A31 AEBE2D5C8BF747A9
    6CA405593A3B5154

5
In  BF213BFD04E8A24A 0CC86A4D9B9C6A31 AEBE2D5C8BF747A9
    6CA405593A3B5154
XorT BF213BFD04E8A24F 0CC86A4D9B9C6A31 AEBE2D5C8BF747A9
    6CA405593A3B5154
Dec  F1D28EA6295891E8 0CC86A4D9B9C6A31 F60E0CDB7F429FE8
    6CA405593A3B5154

4
In  F1D28EA6295891E8 0CC86A4D9B9C6A31 F60E0CDB7F429FE8
    6CA405593A3B5154
XorT F1D28EA6295891EC 0CC86A4D9B9C6A31 F60E0CDB7F429FE8
    6CA405593A3B5154
Dec  9DF8F5405FBC00C2 F661BD9F31FBFA31 F60E0CDB7F429FE8
    6CA405593A3B5154

```

3

```

In      9DF8F5405FBC00C2 F661BD9F31FBFA31 F60E0CDB7F429FE8
        6CA405593A3B5154
XorT    9DF8F5405FBC00C1 F661BD9F31FBFA31 F60E0CDB7F429FE8
        6CA405593A3B5154
Dec     D450EA5C5BBCB563 F661BD9F31FBFA31 F60E0CDB7F429FE8
        0001020304050607

```

2

```

In      D450EA5C5BBCB563 F661BD9F31FBFA31 F60E0CDB7F429FE8
        0001020304050607
XorT    D450EA5C5BBCB561 F661BD9F31FBFA31 F60E0CDB7F429FE8
        0001020304050607
Dec     794314D454E3FDE0 F661BD9F31FBFA31 8899AABBCCDDEEFF
        0001020304050607

```

1

```

In      794314D454E3FDE0 F661BD9F31FBFA31 8899AABBCCDDEEFF
        0001020304050607
XorT    794314D454E3FDE1 F661BD9F31FBFA31 8899AABBCCDDEEFF
        0001020304050607
Dec     A6A6A6A6A6A6A6A6 0011223344556677 8899AABBCCDDEEFF
        0001020304050607

```

```

Plaintext A6A6A6A6A6A6A6A6 0011223344556677
          8899AABBCCDDEEFF 0001020304050607

```

Output:

Key Data: 00112233445566778899AABBCCDDEEFF0001020304050607

4.6 Wrap 256 bits of Key Data with a 256-bit KEK

Input:

KEK:

000102030405060708090A0B0C0D0E0F101112131415161718191A1B1C1D1E1F

Key Data:

00112233445566778899AABBCCDDEEFF000102030405060708090A0B0C0D0E0F

Wrap:

Step	t	A/R3	R1/R4	R2
1				
In		A6A6A6A6A6A6A6A6 0001020304050607	0011223344556677 08090A0B0C0D0E0F	8899AABBCCDDEEFF
Enc		794314D454E3FDE1 0001020304050607	F661BD9F31FBFA31 08090A0B0C0D0E0F	8899AABBCCDDEEFF
XorT		794314D454E3FDE0 0001020304050607	F661BD9F31FBFA31 08090A0B0C0D0E0F	8899AABBCCDDEEFF
2				
In		794314D454E3FDE0 0001020304050607	F661BD9F31FBFA31 08090A0B0C0D0E0F	8899AABBCCDDEEFF
Enc		D450EA5C5BBCB561 0001020304050607	F661BD9F31FBFA31 08090A0B0C0D0E0F	F60E0CDB7F429FE8
XorT		D450EA5C5BBCB563 0001020304050607	F661BD9F31FBFA31 08090A0B0C0D0E0F	F60E0CDB7F429FE8
3				
In		D450EA5C5BBCB563 0001020304050607	F661BD9F31FBFA31 08090A0B0C0D0E0F	F60E0CDB7F429FE8
Enc		9DF8F5405FBC00C1 6CA405593A3B5154	F661BD9F31FBFA31 08090A0B0C0D0E0F	F60E0CDB7F429FE8
XorT		9DF8F5405FBC00C2 6CA405593A3B5154	F661BD9F31FBFA31 08090A0B0C0D0E0F	F60E0CDB7F429FE8
4				
In		9DF8F5405FBC00C2 6CA405593A3B5154	F661BD9F31FBFA31 08090A0B0C0D0E0F	F60E0CDB7F429FE8
Enc		564408FDD0DD2EA4 6CA405593A3B5154	F661BD9F31FBFA31 E5923CB9FDB56FBC	F60E0CDB7F429FE8
XorT		564408FDD0DD2EA0 6CA405593A3B5154	F661BD9F31FBFA31 E5923CB9FDB56FBC	F60E0CDB7F429FE8
5				
In		564408FDD0DD2EA0 6CA405593A3B5154	F661BD9F31FBFA31 E5923CB9FDB56FBC	F60E0CDB7F429FE8
Enc		4EF02EDD3146AFBB 6CA405593A3B5154	E7D1194D853E53F8 E5923CB9FDB56FBC	F60E0CDB7F429FE8
XorT		4EF02EDD3146AFBE 6CA405593A3B5154	E7D1194D853E53F8 E5923CB9FDB56FBC	F60E0CDB7F429FE8

6

In	4EF02EDD3146AFBE	E7D1194D853E53F8	F60E0CDB7F429FE8
	6CA405593A3B5154	E5923CB9FDB56FBC	
Enc	963AAFFD96B223EC	E7D1194D853E53F8	EFD48BA304945576
	6CA405593A3B5154	E5923CB9FDB56FBC	
XorT	963AAFFD96B223EA	E7D1194D853E53F8	EFD48BA304945576
	6CA405593A3B5154	E5923CB9FDB56FBC	

7

In	963AAFFD96B223EA	E7D1194D853E53F8	EFD48BA304945576
	6CA405593A3B5154	E5923CB9FDB56FBC	
Enc	66D7A8ADD086B9DD	E7D1194D853E53F8	EFD48BA304945576
	C365B66943E2D760	E5923CB9FDB56FBC	
XorT	66D7A8ADD086B9DA	E7D1194D853E53F8	EFD48BA304945576
	C365B66943E2D760	E5923CB9FDB56FBC	

8

In	66D7A8ADD086B9DA	E7D1194D853E53F8	EFD48BA304945576
	C365B66943E2D760	E5923CB9FDB56FBC	
Enc	C58B9D3AC6D5B94E	E7D1194D853E53F8	EFD48BA304945576
	C365B66943E2D760	73E3B6CBE5D05D74	
XorT	C58B9D3AC6D5B946	E7D1194D853E53F8	EFD48BA304945576
	C365B66943E2D760	73E3B6CBE5D05D74	

9

In	C58B9D3AC6D5B946	E7D1194D853E53F8	EFD48BA304945576
	C365B66943E2D760	73E3B6CBE5D05D74	
Enc	1A681354E84C41F8	D6AE29ECE7192D43	EFD48BA304945576
	C365B66943E2D760	73E3B6CBE5D05D74	
XorT	1A681354E84C41F1	D6AE29ECE7192D43	EFD48BA304945576
	C365B66943E2D760	73E3B6CBE5D05D74	

10

In	1A681354E84C41F1	D6AE29ECE7192D43	EFD48BA304945576
	C365B66943E2D760	73E3B6CBE5D05D74	
Enc	DBA417FB51F9E3CB	D6AE29ECE7192D43	FBEC169FA5C0F6BA
	C365B66943E2D760	73E3B6CBE5D05D74	
XorT	DBA417FB51F9E3C1	D6AE29ECE7192D43	FBEC169FA5C0F6BA
	C365B66943E2D760	73E3B6CBE5D05D74	

11

In	DBA417FB51F9E3C1	D6AE29ECE7192D43	FBEC169FA5C0F6BA
	C365B66943E2D760	73E3B6CBE5D05D74	
Enc	0629EB29A42E4FD9	D6AE29ECE7192D43	FBEC169FA5C0F6BA
	F56701DAF0388216	73E3B6CBE5D05D74	
XorT	0629EB29A42E4FD2	D6AE29ECE7192D43	FBEC169FA5C0F6BA
	F56701DAF0388216	73E3B6CBE5D05D74	


```

12
In    0629EB29A42E4FD2 D6AE29ECE7192D43 FBEC169FA5C0F6BA
      F56701DAF0388216 73E3B6CBE5D05D74
Enc   F9ED8A1429515665 D6AE29ECE7192D43 FBEC169FA5C0F6BA
      F56701DAF0388216 3CF149E90E8C04D9
XorT  F9ED8A1429515669 D6AE29ECE7192D43 FBEC169FA5C0F6BA
      F56701DAF0388216 3CF149E90E8C04D9

13
In    F9ED8A1429515669 D6AE29ECE7192D43 FBEC169FA5C0F6BA
      F56701DAF0388216 3CF149E90E8C04D9
Enc   2E8E2B6BB2016696 4745856AF333F01F FBEC169FA5C0F6BA
      F56701DAF0388216 3CF149E90E8C04D9
XorT  2E8E2B6BB201669B 4745856AF333F01F FBEC169FA5C0F6BA
      F56701DAF0388216 3CF149E90E8C04D9

14
In    2E8E2B6BB201669B 4745856AF333F01F FBEC169FA5C0F6BA
      F56701DAF0388216 3CF149E90E8C04D9
Enc   15342443CB95ADB1 4745856AF333F01F BCA418BBF7DCE60B
      F56701DAF0388216 3CF149E90E8C04D9
XorT  15342443CB95ADBF 4745856AF333F01F BCA418BBF7DCE60B
      F56701DAF0388216 3CF149E90E8C04D9

15
In    15342443CB95ADBF 4745856AF333F01F BCA418BBF7DCE60B
      F56701DAF0388216 3CF149E90E8C04D9
Enc   33FE29365885C4B7 4745856AF333F01F BCA418BBF7DCE60B
      C272E9466AAE98F9 3CF149E90E8C04D9
XorT  33FE29365885C4B8 4745856AF333F01F BCA418BBF7DCE60B
      C272E9466AAE98F9 3CF149E90E8C04D9

16
In    33FE29365885C4B8 4745856AF333F01F BCA418BBF7DCE60B
      C272E9466AAE98F9 3CF149E90E8C04D9
Enc   5075496800978B4A 4745856AF333F01F BCA418BBF7DCE60B
      C272E9466AAE98F9 40F68C91DB49702C
XorT  5075496800978B5A 4745856AF333F01F BCA418BBF7DCE60B
      C272E9466AAE98F9 40F68C91DB49702C

17
In    5075496800978B5A 4745856AF333F01F BCA418BBF7DCE60B
      C272E9466AAE98F9 40F68C91DB49702C
Enc   A5382A26B47551F1 1BB8C765A84195E7 BCA418BBF7DCE60B
      C272E9466AAE98F9 40F68C91DB49702C
XorT  A5382A26B47551E0 1BB8C765A84195E7 BCA418BBF7DCE60B
      C272E9466AAE98F9 40F68C91DB49702C

```

```

18
In    A5382A26B47551E0 1BB8C765A84195E7 BCA418BBF7DCE60B
      C272E9466AAE98F9 40F68C91DB49702C
Enc   F19D80D437EFE8F9 1BB8C765A84195E7 F7EDAD518C960D36
      C272E9466AAE98F9 40F68C91DB49702C
XorT  F19D80D437EFE8EB 1BB8C765A84195E7 F7EDAD518C960D36
      C272E9466AAE98F9 40F68C91DB49702C

19
In    F19D80D437EFE8EB 1BB8C765A84195E7 F7EDAD518C960D36
      C272E9466AAE98F9 40F68C91DB49702C
Enc   B422B444B87A190B 1BB8C765A84195E7 F7EDAD518C960D36
      1CFBF6B4C24CB982 40F68C91DB49702C
XorT  B422B444B87A1918 1BB8C765A84195E7 F7EDAD518C960D36
      1CFBF6B4C24CB982 40F68C91DB49702C

20
In    B422B444B87A1918 1BB8C765A84195E7 F7EDAD518C960D36
      1CFBF6B4C24CB982 40F68C91DB49702C
Enc   D058823360F88A37 1BB8C765A84195E7 F7EDAD518C960D36
      1CFBF6B4C24CB982 07DFE775B9687E73
XorT  D058823360F88A23 1BB8C765A84195E7 F7EDAD518C960D36
      1CFBF6B4C24CB982 07DFE775B9687E73

21
In    D058823360F88A23 1BB8C765A84195E7 F7EDAD518C960D36
      1CFBF6B4C24CB982 07DFE775B9687E73
Enc   C89A96CA7B163ECC CBCCB35CFB87F826 F7EDAD518C960D36
      1CFBF6B4C24CB982 07DFE775B9687E73
XorT  C89A96CA7B163ED9 CBCCB35CFB87F826 F7EDAD518C960D36
      1CFBF6B4C24CB982 07DFE775B9687E73

22
In    C89A96CA7B163ED9 CBCCB35CFB87F826 F7EDAD518C960D36
      1CFBF6B4C24CB982 07DFE775B9687E73
Enc   39D02FE7435870ED CBCCB35CFB87F826 3F5786E2D80ED326
      1CFBF6B4C24CB982 07DFE775B9687E73
XorT  39D02FE7435870FB CBCCB35CFB87F826 3F5786E2D80ED326
      1CFBF6B4C24CB982 07DFE775B9687E73

23
In    39D02FE7435870FB CBCCB35CFB87F826 3F5786E2D80ED326
      1CFBF6B4C24CB982 07DFE775B9687E73
Enc   0AEB82AE3146A91B CBCCB35CFB87F826 3F5786E2D80ED326
      CBC7F0E71A99F43B 07DFE775B9687E73
XorT  0AEB82AE3146A90C CBCCB35CFB87F826 3F5786E2D80ED326
      CBC7F0E71A99F43B 07DFE775B9687E73

```

24

```

In    0AEB82AE3146A90C CBCCB35CFB87F826 3F5786E2D80ED326
      CBC7F0E71A99F43B 07DFE775B9687E73
Enc   28C9F404C4B810EC CBCCB35CFB87F826 3F5786E2D80ED326
      CBC7F0E71A99F43B FB988B9B7A02DD21
XorT  28C9F404C4B810F4 CBCCB35CFB87F826 3F5786E2D80ED326
      CBC7F0E71A99F43B FB988B9B7A02DD21

```

Output:

```

Ciphertext 28C9F404C4B810F4 CBCCB35CFB87F826 3F5786E2D80ED326
           CBC7F0E71A99F43B FB988B9B7A02DD21

```

Unwrap:

Step t	A/R3	R1/R4	R2
24			
In	28C9F404C4B810F4	CBCCB35CFB87F826	3F5786E2D80ED326
	CBC7F0E71A99F43B	FB988B9B7A02DD21	
XorT	28C9F404C4B810EC	CBCCB35CFB87F826	3F5786E2D80ED326
	CBC7F0E71A99F43B	FB988B9B7A02DD21	
Dec	0AEB82AE3146A90C	CBCCB35CFB87F826	3F5786E2D80ED326
	CBC7F0E71A99F43B	07DFE775B9687E73	
23			
In	0AEB82AE3146A90C	CBCCB35CFB87F826	3F5786E2D80ED326
	CBC7F0E71A99F43B	07DFE775B9687E73	
XorT	0AEB82AE3146A91B	CBCCB35CFB87F826	3F5786E2D80ED326
	CBC7F0E71A99F43B	07DFE775B9687E73	
Dec	39D02FE7435870FB	CBCCB35CFB87F826	3F5786E2D80ED326
	1CFBF6B4C24CB982	07DFE775B9687E73	
22			
In	39D02FE7435870FB	CBCCB35CFB87F826	3F5786E2D80ED326
	1CFBF6B4C24CB982	07DFE775B9687E73	
XorT	39D02FE7435870ED	CBCCB35CFB87F826	3F5786E2D80ED326
	1CFBF6B4C24CB982	07DFE775B9687E73	
Dec	C89A96CA7B163ED9	CBCCB35CFB87F826	F7EDAD518C960D36
	1CFBF6B4C24CB982	07DFE775B9687E73	
21			
In	C89A96CA7B163ED9	CBCCB35CFB87F826	F7EDAD518C960D36
	1CFBF6B4C24CB982	07DFE775B9687E73	
XorT	C89A96CA7B163ECC	CBCCB35CFB87F826	F7EDAD518C960D36
	1CFBF6B4C24CB982	07DFE775B9687E73	
Dec	D058823360F88A23	1BB8C765A84195E7	F7EDAD518C960D36
	1CFBF6B4C24CB982	07DFE775B9687E73	

```

20
In    D058823360F88A23 1BB8C765A84195E7 F7EDAD518C960D36
      1CFBF6B4C24CB982 07DFE775B9687E73
XorT  D058823360F88A37 1BB8C765A84195E7 F7EDAD518C960D36
      1CFBF6B4C24CB982 07DFE775B9687E73
Dec   B422B444B87A1918 1BB8C765A84195E7 F7EDAD518C960D36
      1CFBF6B4C24CB982 40F68C91DB49702C

19
In    B422B444B87A1918 1BB8C765A84195E7 F7EDAD518C960D36
      1CFBF6B4C24CB982 40F68C91DB49702C
XorT  B422B444B87A190B 1BB8C765A84195E7 F7EDAD518C960D36
      1CFBF6B4C24CB982 40F68C91DB49702C
Dec   F19D80D437EFE8EB 1BB8C765A84195E7 F7EDAD518C960D36
      C272E9466AAE98F9 40F68C91DB49702C

18
In    F19D80D437EFE8EB 1BB8C765A84195E7 F7EDAD518C960D36
      C272E9466AAE98F9 40F68C91DB49702C
XorT  F19D80D437EFE8F9 1BB8C765A84195E7 F7EDAD518C960D36
      C272E9466AAE98F9 40F68C91DB49702C
Dec   A5382A26B47551E0 1BB8C765A84195E7 BCA418BBF7DCE60B
      C272E9466AAE98F9 40F68C91DB49702C

17
In    A5382A26B47551E0 1BB8C765A84195E7 BCA418BBF7DCE60B
      C272E9466AAE98F9 40F68C91DB49702C
XorT  A5382A26B47551F1 1BB8C765A84195E7 BCA418BBF7DCE60B
      C272E9466AAE98F9 40F68C91DB49702C
Dec   5075496800978B5A 4745856AF333F01F BCA418BBF7DCE60B
      C272E9466AAE98F9 40F68C91DB49702C

16
In    5075496800978B5A 4745856AF333F01F BCA418BBF7DCE60B
      C272E9466AAE98F9 40F68C91DB49702C
XorT  5075496800978B4A 4745856AF333F01F BCA418BBF7DCE60B
      C272E9466AAE98F9 40F68C91DB49702C
Dec   33FE29365885C4B8 4745856AF333F01F BCA418BBF7DCE60B
      C272E9466AAE98F9 3CF149E90E8C04D9

15
In    33FE29365885C4B8 4745856AF333F01F BCA418BBF7DCE60B
      C272E9466AAE98F9 3CF149E90E8C04D9
XorT  33FE29365885C4B7 4745856AF333F01F BCA418BBF7DCE60B
      C272E9466AAE98F9 3CF149E90E8C04D9
Dec   15342443CB95ADBF 4745856AF333F01F BCA418BBF7DCE60B
      F56701DAF0388216 3CF149E90E8C04D9

```

```

14
In    15342443CB95ADBF 4745856AF333F01F BCA418BBF7DCE60B
      F56701DAF0388216 3CF149E90E8C04D9
XorT  15342443CB95ADB1 4745856AF333F01F BCA418BBF7DCE60B
      F56701DAF0388216 3CF149E90E8C04D9
Dec   2E8E2B6BB201669B 4745856AF333F01F FBEC169FA5C0F6BA
      F56701DAF0388216 3CF149E90E8C04D9

13
In    2E8E2B6BB201669B 4745856AF333F01F FBEC169FA5C0F6BA
      F56701DAF0388216 3CF149E90E8C04D9
XorT  2E8E2B6BB201669B 4745856AF333F01F FBEC169FA5C0F6BA
      F56701DAF0388216 3CF149E90E8C04D9
Dec   F9ED8A1429515669 D6AE29ECE7192D43 FBEC169FA5C0F6BA
      F56701DAF0388216 3CF149E90E8C04D9

12
In    F9ED8A1429515669 D6AE29ECE7192D43 FBEC169FA5C0F6BA
      F56701DAF0388216 3CF149E90E8C04D9
XorT  F9ED8A1429515665 D6AE29ECE7192D43 FBEC169FA5C0F6BA
      F56701DAF0388216 3CF149E90E8C04D9
Dec   0629EB29A42E4FD2 D6AE29ECE7192D43 FBEC169FA5C0F6BA
      F56701DAF0388216 73E3B6CBE5D05D74

11
In    0629EB29A42E4FD2 D6AE29ECE7192D43 FBEC169FA5C0F6BA
      F56701DAF0388216 73E3B6CBE5D05D74
XorT  0629EB29A42E4FD9 D6AE29ECE7192D43 FBEC169FA5C0F6BA
      F56701DAF0388216 73E3B6CBE5D05D74
Dec   DBA417FB51F9E3C1 D6AE29ECE7192D43 FBEC169FA5C0F6BA
      C365B66943E2D760 73E3B6CBE5D05D74

10
In    DBA417FB51F9E3C1 D6AE29ECE7192D43 FBEC169FA5C0F6BA
      C365B66943E2D760 73E3B6CBE5D05D74
XorT  DBA417FB51F9E3CB D6AE29ECE7192D43 FBEC169FA5C0F6BA
      C365B66943E2D760 73E3B6CBE5D05D74
Dec   1A681354E84C41F1 D6AE29ECE7192D43 EFD48BA304945576
      C365B66943E2D760 73E3B6CBE5D05D74

9
In    1A681354E84C41F1 D6AE29ECE7192D43 EFD48BA304945576
      C365B66943E2D760 73E3B6CBE5D05D74
XorT  1A681354E84C41F8 D6AE29ECE7192D43 EFD48BA304945576
      C365B66943E2D760 73E3B6CBE5D05D74
Dec   C58B9D3AC6D5B946 E7D1194D853E53F8 EFD48BA304945576
      C365B66943E2D760 73E3B6CBE5D05D74

```

```

8
In   C58B9D3AC6D5B946 E7D1194D853E53F8 EFD48BA304945576
      C365B66943E2D760 73E3B6CBE5D05D74
XorT C58B9D3AC6D5B94E E7D1194D853E53F8 EFD48BA304945576
      C365B66943E2D760 73E3B6CBE5D05D74
Dec  66D7A8ADD086B9DA E7D1194D853E53F8 EFD48BA304945576
      C365B66943E2D760 E5923CB9FDB56FBC

7
In   66D7A8ADD086B9DA E7D1194D853E53F8 EFD48BA304945576
      C365B66943E2D760 E5923CB9FDB56FBC
XorT 66D7A8ADD086B9DD E7D1194D853E53F8 EFD48BA304945576
      C365B66943E2D760 E5923CB9FDB56FBC
Dec  963AAFFD96B223EA E7D1194D853E53F8 EFD48BA304945576
      6CA405593A3B5154 E5923CB9FDB56FBC

6
In   963AAFFD96B223EA E7D1194D853E53F8 EFD48BA304945576
      6CA405593A3B5154 E5923CB9FDB56FBC
XorT 963AAFFD96B223EC E7D1194D853E53F8 EFD48BA304945576
      6CA405593A3B5154 E5923CB9FDB56FBC
Dec  4EF02EDD3146AFBE E7D1194D853E53F8 F60E0CDB7F429FE8
      6CA405593A3B5154 E5923CB9FDB56FBC

5
In   4EF02EDD3146AFBE E7D1194D853E53F8 F60E0CDB7F429FE8
      6CA405593A3B5154 E5923CB9FDB56FBC
XorT 4EF02EDD3146AFBB E7D1194D853E53F8 F60E0CDB7F429FE8
      6CA405593A3B5154 E5923CB9FDB56FBC
Dec  564408FDD0DD2EA0 F661BD9F31FBFA31 F60E0CDB7F429FE8
      6CA405593A3B5154 E5923CB9FDB56FBC

4
In   564408FDD0DD2EA0 F661BD9F31FBFA31 F60E0CDB7F429FE8
      6CA405593A3B5154 E5923CB9FDB56FBC
XorT 564408FDD0DD2EA4 F661BD9F31FBFA31 F60E0CDB7F429FE8
      6CA405593A3B5154 E5923CB9FDB56FBC
Dec  9DF8F5405FBC00C2 F661BD9F31FBFA31 F60E0CDB7F429FE8
      6CA405593A3B5154 08090A0B0C0D0E0F

3
In   9DF8F5405FBC00C2 F661BD9F31FBFA31 F60E0CDB7F429FE8
      6CA405593A3B5154 08090A0B0C0D0E0F
XorT 9DF8F5405FBC00C1 F661BD9F31FBFA31 F60E0CDB7F429FE8
      6CA405593A3B5154 08090A0B0C0D0E0F
Dec  D450EA5C5BBCB563 F661BD9F31FBFA31 F60E0CDB7F429FE8
      0001020304050607 08090A0B0C0D0E0F

```

2

```

In    D450EA5C5BBCB563 F661BD9F31FBFA31 F60E0CDB7F429FE8
      0001020304050607 08090A0B0C0D0E0F
XorT  D450EA5C5BBCB561 F661BD9F31FBFA31 F60E0CDB7F429FE8
      0001020304050607 08090A0B0C0D0E0F
Dec   794314D454E3FDE0 F661BD9F31FBFA31 8899AABBCCDDEEFF
      0001020304050607 08090A0B0C0D0E0F

```

1

```

In    794314D454E3FDE0 F661BD9F31FBFA31 8899AABBCCDDEEFF
      0001020304050607 08090A0B0C0D0E0F
XorT  794314D454E3FDE1 F661BD9F31FBFA31 8899AABBCCDDEEFF
      0001020304050607 08090A0B0C0D0E0F
Dec   A6A6A6A6A6A6A6A6 0011223344556677 8899AABBCCDDEEFF
      0001020304050607 08090A0B0C0D0E0F

```

```

Plaintext  A6A6A6A6A6A6A6A6 0011223344556677 8899AABBCCDDEEFF
           0001020304050607 08090A0B0C0D0E0F

```

Output:

Key Data:

```
00112233445566778899AABBCCDDEEFF000102030405060708090A0B0C0D0E0F
```

5. Security Considerations

The key wrap algorithm includes a strong integrity check on the key data. If unwrapping produces the expected check value in A[0], then the chance that the key data is corrupt is 2^{-64} . If unwrapping produces an unexpected value, then the algorithm implementation MUST return an error, and it MUST NOT return any key data.

Implementations must protect the KEK from disclosure. Compromise of the KEK may result in the disclosure of all key data protected with that KEK.

6. References

- AES National Institute of Standards and Technology. FIPS Pub 197: Advanced Encryption Standard (AES). 26 November 2001.
- AES-WRAP National Institute of Standards and Technology. AES Key Wrap Specification. 17 November 2001.
[<http://csrc.nist.gov/encryption/kms/key-wrap.pdf>]

7. Acknowledgments

Most of the text in this document is taken from [AES-WRAP]. The authors of that document are responsible for the development of the AES key wrap algorithm.

8. Authors' Addresses

Jim Schaad
Soaring Hawk Consulting

EMail: jimsch@exmsft.com

Russell Housley
RSA Laboratories
918 Spring Knoll Drive
Herndon, VA 20170
USA

EMail: rhousley@rsasecurity.com

9. Full Copyright Statement

Copyright (C) The Internet Society (2002). All Rights Reserved.

This document and translations of it may be copied and furnished to others provided that the above copyright notice and this paragraph are included on all such copies. However, this document itself may not be modified in any way, such as by removing the copyright notice or references to the Internet Society or other Internet organizations, except as required to translate it into languages other than English.

The limited permissions granted above are perpetual and will not be revoked by the Internet Society or its successors or assigns.

This document and the information contained herein is provided on an "AS IS" basis and THE INTERNET SOCIETY AND THE INTERNET ENGINEERING TASK FORCE DISCLAIMS ALL WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY WARRANTY THAT THE USE OF THE INFORMATION HEREIN WILL NOT INFRINGE ANY RIGHTS OR ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

Acknowledgement

Funding for the RFC Editor function is currently provided by the Internet Society.

