

Advanced Encryption Standard (AES) Key Wrap Algorithm

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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
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 A_0 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 $s = 6n$
 $A[t] = \text{MSB}(64, \text{AES}(K, A[t-1] \parallel R[t-1][1])) \wedge t$
 For $i = 1$ to $n-1$
 $R[t][i] = R[t-1][i+1]$
 $R[t][n] = \text{LSB}(64, \text{AES}(K, A[t-1] \parallel R[t-1][1]))$

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 4CE414878463EAAAC 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 0011223344556677 8899AABBCCDDEEFF
      0001020304050607
Enc   DFE8FD5D1A3786A7 351D385096CCFB29 8899AABBCCDDEEFF
      0001020304050607
XorT   DFE8FD5D1A3786A6 351D385096CCFB29 8899AABBCCDDEEFF
      0001020304050607

2
In   DFE8FD5D1A3786A6 351D385096CCFB29 8899AABBCCDDEEFF
      0001020304050607
Enc   9D9B32B9ED742E02 351D385096CCFB29 51F22F3286758A2D
      0001020304050607
XorT   9D9B32B9ED742E00 351D385096CCFB29 51F22F3286758A2D
      0001020304050607

```

3

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

4

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

5

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

6

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

7

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

8

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

9

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

10

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

11

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

12

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

13

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

14

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

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 6F85BFBD7E880E3 0CC86A4D9B9C6A31 AEBE2D5C8BF747A9
39EBC1A1A53FF55B
XorT 6F85BFBD7E880E5 0CC86A4D9B9C6A31 AEBE2D5C8BF747A9
39EBC1A1A53FF55B

7

In 6F85BFBD7E880E5 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 F6E6F4FBE30E71E4 769C8B80A32CB895
8CD5D17D6B254DA1
XorT A8F9BC1612C68B2D F6E6F4FBE30E71E4 769C8B80A32CB895
8CD5D17D6B254DA1
Dec 39128CE5E435F3B1 F6E6F4FBE30E71E4 769C8B80A32CB895
C490C33642717146

17

In 39128CE5E435F3B1 F6E6F4FBE30E71E4 769C8B80A32CB895
C490C33642717146
XorT 39128CE5E435F3A0 F6E6F4FBE30E71E4 769C8B80A32CB895
C490C33642717146
Dec C9F5F26A378011CE F6E6F4FBE30E71E4 D36F4FFBA2C82ED9
C490C33642717146

16

In C9F5F26A378011CE F6E6F4FBE30E71E4 D36F4FFBA2C82ED9
C490C33642717146
XorT C9F5F26A378011DE F6E6F4FBE30E71E4 D36F4FFBA2C82ED9
C490C33642717146
Dec 1BF2B1CD947311B9 FB1F2965FCE1E783 D36F4FFBA2C82ED9
C490C33642717146

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 6F85BFBD7E880E5 0CC86A4D9B9C6A31 AEBE2D5C8BF747A9
39EBC1A1A53FF55B

6

In 6F85BFBD7E880E5 0CC86A4D9B9C6A31 AEBE2D5C8BF747A9
39EBC1A1A53FF55B
XorT 6F85BFBD7E880E3 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	0011223344556677	8899AABBCCDDEEFF
		0001020304050607	08090A0B0C0D0E0F	
Enc		794314D454E3FDE1	F661BD9F31FBFA31	8899AABBCCDDEEFF
		0001020304050607	08090A0B0C0D0E0F	
XorT		794314D454E3FDE0	F661BD9F31FBFA31	8899AABBCCDDEEFF
		0001020304050607	08090A0B0C0D0E0F	
2				
In		794314D454E3FDE0	F661BD9F31FBFA31	8899AABBCCDDEEFF
		0001020304050607	08090A0B0C0D0E0F	
Enc		D450EA5C5BBCB561	F661BD9F31FBFA31	F60E0CDB7F429FE8
		0001020304050607	08090A0B0C0D0E0F	
XorT		D450EA5C5BBCB563	F661BD9F31FBFA31	F60E0CDB7F429FE8
		0001020304050607	08090A0B0C0D0E0F	
3				
In		D450EA5C5BBCB563	F661BD9F31FBFA31	F60E0CDB7F429FE8
		0001020304050607	08090A0B0C0D0E0F	
Enc		9DF8F5405FBC00C1	F661BD9F31FBFA31	F60E0CDB7F429FE8
		6CA405593A3B5154	08090A0B0C0D0E0F	
XorT		9DF8F5405FBC00C2	F661BD9F31FBFA31	F60E0CDB7F429FE8
		6CA405593A3B5154	08090A0B0C0D0E0F	
4				
In		9DF8F5405FBC00C2	F661BD9F31FBFA31	F60E0CDB7F429FE8
		6CA405593A3B5154	08090A0B0C0D0E0F	
Enc		564408FDD0DD2EA4	F661BD9F31FBFA31	F60E0CDB7F429FE8
		6CA405593A3B5154	E5923CB9FDB56FBC	
XorT		564408FDD0DD2EA0	F661BD9F31FBFA31	F60E0CDB7F429FE8
		6CA405593A3B5154	E5923CB9FDB56FBC	
5				
In		564408FDD0DD2EA0	F661BD9F31FBFA31	F60E0CDB7F429FE8
		6CA405593A3B5154	E5923CB9FDB56FBC	
Enc		4EF02EDD3146AFBB	E7D1194D853E53F8	F60E0CDB7F429FE8
		6CA405593A3B5154	E5923CB9FDB56FBC	
XorT		4EF02EDD3146AFBE	E7D1194D853E53F8	F60E0CDB7F429FE8
		6CA405593A3B5154	E5923CB9FDB56FBC	

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  2E8E2B6BB2016696 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.

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