

---

Stream: Internet Engineering Task Force (IETF)  
RFC: [9964](#)  
Category: Standards Track  
Published: May 2026  
ISSN: 2070-1721  
Authors: M. Prorock O. Steele  
*Tradeverifyd Tradeverifyd*

# RFC 9964

## ML-DSA for JSON Object Signing and Encryption (JOSE) and CBOR Object Signing and Encryption (COSE)

---

### Abstract

This document specifies JSON Object Signing and Encryption (JOSE) and CBOR Object Signing and Encryption (COSE) serializations for the Module-Lattice-Based Digital Signature Standard (ML-DSA), a Post-Quantum Cryptography (PQC) digital signature scheme defined in US NIST FIPS 204.

### Status of This Memo

This is an Internet Standards Track document.

This document is a product of the Internet Engineering Task Force (IETF). It represents the consensus of the IETF community. It has received public review and has been approved for publication by the Internet Engineering Steering Group (IESG). Further information on Internet Standards is available in Section 2 of RFC 7841.

Information about the current status of this document, any errata, and how to provide feedback on it may be obtained at <https://www.rfc-editor.org/info/rfc9964>.

### Copyright Notice

Copyright (c) 2026 IETF Trust and the persons identified as the document authors. All rights reserved.

This document is subject to BCP 78 and the IETF Trust's Legal Provisions Relating to IETF Documents (<https://trustee.ietf.org/license-info>) in effect on the date of publication of this document. Please review these documents carefully, as they describe your rights and restrictions

with respect to this document. Code Components extracted from this document must include Revised BSD License text as described in Section 4.e of the Trust Legal Provisions and are provided without warranty as described in the Revised BSD License.

## Table of Contents

1. Introduction	3
2. Terminology	3
3. AKP Key Type	3
4. ML-DSA Private Keys	4
5. ML-DSA Algorithms	5
6. AKP Thumbprints	6
7. Security Considerations	6
7.1. Private Key Compromise	7
7.2. Rationale for Not Supporting HashML-DSA	7
7.3. Validation of Keys	7
7.4. Mismatched AKP Parameters	7
8. IANA Considerations	7
8.1. Additions to Existing Registries	7
8.1.1. New COSE Algorithms	7
8.1.2. New COSE Key Types	8
8.1.3. New COSE Key Type Parameters	9
8.1.4. New JOSE Algorithms	9
8.1.5. New JOSE Key Types	10
8.1.6. New JWK Parameters	11
9. References	11
9.1. Normative References	11
9.2. Informative References	12
Appendix A. Examples	12
A.1. JOSE	12
A.2. COSE	28
Acknowledgments	54

---

<a href="#">Contributors</a>	55
<a href="#">Authors' Addresses</a>	55

## 1. Introduction

This document specifies how to use ML-DSA keys and signatures as described in [FIPS-204] in conjunction with JOSE and COSE. A new key type named Algorithm Key Pair (AKP) is defined to express public and private keys for use with algorithms not limited to those registered in this document. Similarly, a new thumbprint algorithm is defined for AKP to ensure these keys can be compared according to the procedures defined in [RFC7638] and [RFC9679].

## 2. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

Some examples in this specification are truncated using "..." for readability.

## 3. AKP Key Type

This section specifies a generic cryptographic key structure for use with algorithms not limited to those registered in this document. The Algorithm Key Pair (AKP) type is used to express public and private keys for use with algorithms. The concept of public and private information classes for key pairs originates from Section 8.1 of [RFC7517]. The parameters for public and private information classes contain byte strings in a format specified by the `alg` value. The `alg` JSON Web Key (JWK) parameter or COSE Key Common parameter is **REQUIRED** for all AKP keys. The `pub` parameter contains public information and is **REQUIRED**. The `priv` parameter contains private information and **MUST NOT** be present in public keys. Some algorithms may require or recommend additional structure or length checks for associated key type parameters.

When AKP keys are expressed as JWKs, the key parameters are base64url encoded. When AKP keys are expressed as COSE keys, no encoding is needed.

This document introduces the AKP key type in [IANA.jose]:

An example truncated private key for use with ML-DSA-44 in JWK format is provided below:

```

{
  "kid": "T4x170S7MT6Zeq6r9V9fPJGVn76wfnXJ21-gyo0Gu6o",
  "kty": "AKP",
  "alg": "ML-DSA-44",
  "pub": "unH59k4Ru...DZgbTP07e7gEWzw4MFRrndjbDQ",
  "priv": "AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA"
}

```

Figure 1: The All-Zeros ML-DSA-44 JWK

This document introduces the AKP key type in [\[IANA.cose\]](#):

An example truncated private key for use with ML-DSA-44 in COSE\_Key format is provided below:

```

{
  / kid / 2: h'b8969ab4b37da9f068...6f0583bf5b8d3a8059a',
  / kty / 1: 7, / AKP /
  / alg / 3: -48, / ML-DSA-44 /
  / pub / -1: h'ba71f9f64e11baeb589...3830546b9dd8db0d',
  / priv / -2: h'0000000000000000...0000000000000000'
}

```

Figure 2: The All-Zeros ML-DSA-44 COSE Key

## 4. ML-DSA Private Keys

Note that US NIST [\[FIPS-204\]](#) defines 2 expressions for private keys: a seed, and a private key that is expanded from the seed.

Unlike [\[RFC9881\]](#), which supports the expanded private key format to maximize interoperability with existing implementations, this document specifies ML-DSA private key information using only the seed format. The seed format was chosen to provide a single, compact representation that is consistent across both COSE and JOSE, simplifying key management and reducing storage requirements.

For the ML-DSA private keys described in this document, the `priv` parameter **MUST** be the seed and **MUST** have a length of 32 bytes.

This specification intentionally does not define a means of utilizing the expanded private key representation defined by US NIST FIPS so as to increase interoperability by having a single ML-DSA private key representation for COSE and JOSE.

See the [Security Considerations](#) of this document for details.

## 5. ML-DSA Algorithms

The ML-DSA Signature Scheme is parameterized to support different security levels.

In this document, the abbreviations ML-DSA-44, ML-DSA-65, and ML-DSA-87 are used to refer to ML-DSA with the parameter choices given in Table 1 of [FIPS-204].

This document has registered the ML-DSA-44, ML-DSA-65, and ML-DSA-87 algorithms in [IANA.jose] and [IANA.cose].

In accordance with Section 3 of this document, ML-DSA key parameters have the following additional constraints:

- The `pub` parameter is the ML-DSA public key as described in Section 5.3 of US NIST [FIPS-204].
- The size of `pub` and the associated signature for each of these algorithms is defined in Table 2 of US NIST [FIPS-204] and repeated here for convenience:

Algorithm	Private Key	Public Key	Signature Size
ML-DSA-44	2560	1312	2420
ML-DSA-65	4032	1952	3309
ML-DSA-87	4896	2592	4627

Table 1: Sizes (In Bytes) of Keys and Signatures of ML-DSA

Note that `priv` size is always 32 bytes and that `KeyGen_internal` is called to produce the expanded private keys for "Private Key" in the table above.

See Section 4 for further details.

- These algorithms are used to produce signatures as described in Algorithm 2 of US NIST [FIPS-204].
- The `ctx` parameter **MUST** be the empty string for ML-DSA-44, ML-DSA-65, and ML-DSA-87.
- Signatures are encoded as byte strings using the algorithms defined in Section 7.2 of US NIST [FIPS-204].

When producing JSON Web Signatures, the signature byte strings are base64url encoded and the encoded signature size is larger than described in the table above. When producing COSE signatures, no encoding is needed; see Section 4 of [RFC9052] for more details on how COSE signatures are created.

- Table 2 of [FIPS-204] describes the ML-DSA key and signature sizes. ML-DSA produces significantly larger public keys and signatures compared to traditional algorithms. This size increase can create challenges for deployments with limited bandwidth, memory, or

processing capacity. ML-DSA may not be suitable for use cases requiring small keys or signatures. Use of thumbprints as described in [RFC7638] and [RFC9679] can reduce the need to repeat public key representations.

## 6. AKP Thumbprints

Although this document specifies how to represent ML-DSA keys using AKP, the AKP key type and thumbprint computations are suitable for use with algorithms other than ML-DSA.

When computing the COSE Key Thumbprint as described in [RFC9679], the required parameters for AKPs are:

- "kty" (label: 1, data type: int, value: 7)
- "alg" (label: 3, data type: int, value: int)
- "pub" (label: -1, value: bstr)

The COSE Key Thumbprint is produced according to the process described in [Section 3](#) of [RFC9679].

When computing the JWK Thumbprint as described in [RFC7638], the required parameters for AKPs are:

- "kty"
- "alg"
- "pub"

Their lexicographic order, per [Section 3.3](#) of [RFC7638], is:

- "alg"
- "kty"
- "pub"

The JWK Thumbprint is produced according to the process described in [Section 3](#) of [RFC7638].

See the kid values in the JWK and COSE Key examples in [Appendix A](#) for examples of AKP thumbprints.

## 7. Security Considerations

The security considerations of [RFC7515], [RFC7517], and [RFC9053] apply to this specification as well.

A detailed security analysis of ML-DSA is beyond the scope of this specification; see [FIPS-204] for additional details. Implementers should also refer to the security considerations in [RFC9881] for additional guidance on ML-DSA deployment considerations, including discussions on randomized versus deterministic signing approaches.

## 7.1. Private Key Compromise

The seed and the private key expanded from the seed require the same level of protection. If an unauthorized party obtains the seed, or the expanded private key, they can forge signatures. This undermines the authenticity and integrity guarantees provided by ML-DSA, as attackers could impersonate the legitimate signer or alter signed data without detection.

## 7.2. Rationale for Not Supporting HashML-DSA

This document does not specify algorithms for use with HashML-DSA as described in Section 5.4 of [FIPS-204]. As the verify routines are different, future support for HashML-DSA would require the registration of additional algorithms. Section 8.3 of [RFC9881] explains the rationale for disallowing HashML-DSA, including the increased complexity and compatibility concerns with existing implementations.

## 7.3. Validation of Keys

When an AKP algorithm requires or encourages that a key be validated before being used, all algorithm-related key parameters **MUST** be validated.

Section 7.2 of [FIPS-204] describes the encoding of ML-DSA keys and signatures. For Algorithms 22 and 23 (pkEncode and pkDecode), the inputs need to be within the ranges given in the algorithms. For the ML-DSA algorithms registered in this document, the `priv` key parameter is the seed, and therefore, the seed length check **MUST** be performed. The length of the seed is 256 bits, which is 32 bytes. However, when the `priv` parameter is expanded using `KeyGen_internal`, the `skEncode` and `skDecode` algorithms **MUST** be used. [FIPS-204] notes "skDecode should only be run on inputs that come from trusted sources" and that "as the seed can be used to compute the private key, it is sensitive data and shall be treated with the same safeguards as a private key".

## 7.4. Mismatched AKP Parameters

When using an AKP key with an algorithm, it is possible that the public and private information class parameters have been tampered with or mismatched. Depending on the algorithm and implementation, the consequences of using mismatched parameters can range from operations failing to private key compromise.

# 8. IANA Considerations

## 8.1. Additions to Existing Registries

### 8.1.1. New COSE Algorithms

IANA has registered the following entries in the "COSE Algorithms" registry. The following completed registration actions are provided as described in [RFC9053] and [RFC9054].

#### 8.1.1.1. ML-DSA-44

Name: ML-DSA-44

Value: -48

Description: CBOR Object Signing Algorithm for ML-DSA-44

Capabilities: [kty]

Change Controller: IETF

Reference: RFC 9964

Recommended: Yes

#### **8.1.1.2. ML-DSA-65**

Name: ML-DSA-65

Value: -49

Description: CBOR Object Signing Algorithm for ML-DSA-65

Capabilities: [kty]

Change Controller: IETF

Reference: RFC 9964

Recommended: Yes

#### **8.1.1.3. ML-DSA-87**

Name: ML-DSA-87

Value: -50

Description: CBOR Object Signing Algorithm for ML-DSA-87

Capabilities: [kty]

Change Controller: IETF

Reference: RFC 9964

Recommended: Yes

### **8.1.2. New COSE Key Types**

IANA registered the following entry in the "COSE Key Types" registry. The following completed registration template is provided as described in [\[RFC9053\]](#).

#### **8.1.2.1. AKP**

Name: AKP

Value: 7

Description: COSE Key Type for Algorithm Key Pairs

Capabilities: [kty(7)]

Change Controller: IETF

Reference: RFC 9964

### 8.1.3. New COSE Key Type Parameters

IANA has registered the following entries in the "COSE Key Type Parameters" registry. The following completed registration templates are provided as described in [\[RFC9053\]](#).

#### 8.1.3.1. AKP Public Key

Key Type: 7

Name: pub

Label: -1

CBOR Type: bstr

Description: Public key

Reference: RFC 9964

#### 8.1.3.2. AKP Private Key

Key Type: 7

Name: priv

Label: -2

CBOR Type: bstr

Description: Private key

Reference: RFC 9964

### 8.1.4. New JOSE Algorithms

IANA has registered the following entries in the "JSON Web Signature and Encryption Algorithms" registry. The following completed registrations are provided as described in [\[RFC7518\]](#).

#### 8.1.4.1. ML-DSA-44

Algorithm Name: ML-DSA-44

Algorithm Description: ML-DSA-44 as described in US NIST FIPS 204

Algorithm Usage Location(s): alg

JOSE Implementation Requirements: Optional

Change Controller: IETF

Specification Document(s): RFC 9964

Algorithm Analysis Documents(s): [\[FIPS-204\]](#)

#### **8.1.4.2. ML-DSA-65**

Algorithm Name: ML-DSA-65

Algorithm Description: ML-DSA-65 as described in US NIST FIPS 204

Algorithm Usage Location(s): alg

JOSE Implementation Requirements: Optional

Change Controller: IETF

Specification Document(s): RFC 9964

Algorithm Analysis Documents(s): [\[FIPS-204\]](#)

#### **8.1.4.3. ML-DSA-87**

Algorithm Name: ML-DSA-87

Algorithm Description: ML-DSA-87 as described in US NIST FIPS 204

Algorithm Usage Location(s): alg

JOSE Implementation Requirements: Optional

Change Controller: IETF

Specification Document(s): RFC 9964

Algorithm Analysis Documents(s): [\[FIPS-204\]](#)

### **8.1.5. New JOSE Key Types**

IANA has registered the following entry in the "JSON Web Key Types" registry. The following completed registration is provided as described in [\[RFC7518\]](#) and [\[RFC7638\]](#).

#### **8.1.5.1. AKP**

"kty" Parameter Value: AKP

Key Type Description: Algorithm Key Pair

JOSE Implementation Requirements: Optional

Change Controller: IETF

Specification Document(s): RFC 9964

### 8.1.6. New JWK Parameters

IANA has registered the following entry in the "JSON Web Key Parameters" registry. The following completed registrations are provided as described in [RFC7517] and [RFC7638].

#### 8.1.6.1. AKP Public Key

Parameter Name: pub

Parameter Description: Public key

Used with "kty" Value(s): AKP

Parameter Information Class: Public

Change Controller: IETF

Specification Document(s): RFC 9964

#### 8.1.6.2. AKP Private Key

Parameter Name: priv

Parameter Description: Private key

Used with "kty" Value(s): AKP

Parameter Information Class: Private

Change Controller: IETF

Specification Document(s): RFC 9964

## 9. References

### 9.1. Normative References

[FIPS-204] NIST, "Module-Lattice-Based Digital Signature Standard", NIST FIPS 204, DOI 10.6028/NIST.FIPS.204, August 2024, <<https://nvlpubs.nist.gov/nistpubs/FIPS/NIST.FIPS.204.pdf>>.

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <<https://www.rfc-editor.org/info/rfc2119>>.

- 
- [RFC7515] Jones, M., Bradley, J., and N. Sakimura, "JSON Web Signature (JWS)", RFC 7515, DOI 10.17487/RFC7515, May 2015, <<https://www.rfc-editor.org/info/rfc7515>>.
  - [RFC7517] Jones, M., "JSON Web Key (JWK)", RFC 7517, DOI 10.17487/RFC7517, May 2015, <<https://www.rfc-editor.org/info/rfc7517>>.
  - [RFC7518] Jones, M., "JSON Web Algorithms (JWA)", RFC 7518, DOI 10.17487/RFC7518, May 2015, <<https://www.rfc-editor.org/info/rfc7518>>.
  - [RFC7638] Jones, M. and N. Sakimura, "JSON Web Key (JWK) Thumbprint", RFC 7638, DOI 10.17487/RFC7638, September 2015, <<https://www.rfc-editor.org/info/rfc7638>>.
  - [RFC8174] Leiba, B., "Ambiguity of Uppercase vs Lowercase in RFC 2119 Key Words", BCP 14, RFC 8174, DOI 10.17487/RFC8174, May 2017, <<https://www.rfc-editor.org/info/rfc8174>>.
  - [RFC9052] Schaad, J., "CBOR Object Signing and Encryption (COSE): Structures and Process", STD 96, RFC 9052, DOI 10.17487/RFC9052, August 2022, <<https://www.rfc-editor.org/info/rfc9052>>.
  - [RFC9053] Schaad, J., "CBOR Object Signing and Encryption (COSE): Initial Algorithms", RFC 9053, DOI 10.17487/RFC9053, August 2022, <<https://www.rfc-editor.org/info/rfc9053>>.
  - [RFC9054] Schaad, J., "CBOR Object Signing and Encryption (COSE): Hash Algorithms", RFC 9054, DOI 10.17487/RFC9054, August 2022, <<https://www.rfc-editor.org/info/rfc9054>>.
  - [RFC9679] Isobe, K., Tschofenig, H., and O. Steele, "CBOR Object Signing and Encryption (COSE) Key Thumbprint", RFC 9679, DOI 10.17487/RFC9679, December 2024, <<https://www.rfc-editor.org/info/rfc9679>>.

## 9.2. Informative References

- [IANA.cose] IANA, "CBOR Object Signing and Encryption (COSE)", <<https://www.iana.org/assignments/cose>>.
- [IANA.jose] IANA, "JSON Object Signing and Encryption (JOSE)", <<https://www.iana.org/assignments/jose>>.
- [RFC9881] Massimo, J., Kampanakis, P., Turner, S., and B. E. Westerbaan, "Internet X.509 Public Key Infrastructure -- Algorithm Identifiers for the Module-Lattice-Based Digital Signature Algorithm (ML-DSA)", RFC 9881, DOI 10.17487/RFC9881, October 2025, <<https://www.rfc-editor.org/info/rfc9881>>.

## Appendix A. Examples

### A.1. JOSE



```

hyKEpbb4M5KQsJ3AsENCroVmQ5QIv3K2XNRkve4vjBmP6sV2b6GSY_UeRvPElA7SUGbGtKbn
-c0aYhBuB8p1PhRTBa55_cFqAmNmavF1-fdMktJuIaH2f-K0zZCzbHw54998T7kIWgyMsyGC
AvynEB_kh0QwT7tCjg5HQ8SIjdnRYW0kjZfjt5LJbGA-PnRo8gPVQVGeYDP2vsSXhNJY94Ai
tKCY1srcSsuYDrhNBKrn0J1uEsMPVHsgFw_ZHMyAEaVQughSNW4fm8q6_1Nv4zLutDITzmAL
6a6i6-WS6QRIs_4VUtwr5cXXIFDDeHVWeGcNivQ6W9urEUP4crguiq7z_DTiYaGfUksub-T7
mw0zU8Z0Sd5pUTpJLv-IYIUAl6CscHvunnRLEKqpW1Sa1dcFzS5VP4Afr3mg7wX4Vlq1AHn
pFxE2L1LZiKoTc9jDE0vTDkxr86gMkwMm6RdyPF_q48AVJ1br8Qp88-4B84X52zZ5cw-IJYe
-HiVJ29LpeYm340_rWivpy-UB5i9TK1Mrxf94y1okzZTPbP3_v1_XX0nE7RTLz98EA96euJ7
l3EpbEqks7mh6i1FJNnvLM_u29sYobJ6PUT-i1VlQnF_JBARKEz74pBxm115Y5Lo15rsIla
QHInUBC08fHCHI59LAFKusN4JmodDqLYwkWijEL_sfrC6LtrbXqpM1pw09zSrs_tS1RQ-LnW
HuPrU5KLCzv53JKrh8lU_cdBowe_F-Ib_Ui4bQ2FME-0mnyG0XijHUsrGMZ9dfowvIkr83Jp
qw1FOZAwMmSGPNPEJRw9kDshjotndUB5S1UCfv_U4IoVn7WgvxeCS-BBxqyWfh7YTdf73Enm
GwVYxVj1XaHCeeTZmUacnT4MQUAcBfJtq6BB1boAQGWP2FZWpd6HNnruv744VeWmfGk9z55
67wFhwuXmkmE2xvDo4wP80xutjUfsePx5YkLxhY1XsWqTZr19tInxJWWq8RLZsWPmtq5WZ5u
cBMasClp0ABenYZdSACQNhC73wLS0Z2s1HQhBoIl7l1r1p372LZs_Seu1u_8Fo7DoJqRpKaNo
c2_JUMmn7TUZS8zLyzxgeq8R8iNbRP20DwDBNXocsTDBKaQrtB-QiEPySQtJa4G61XeNZyh5
aGzfoWZ90mjZG9pbbehcqwIrt-ESjPyeT6sfSrv0fTzr7fBXwpUs2rS4Br1Nse5g_h8CQiik
8aaOTOEPkXiyg4s5DewRlgDZHS-3g-YXPUiBN062_HxknkMpkJvKW-tkVDbgtxvy4nG80u16
W_KeRsoEKDTRYNKZWXjZITNa0h6agnwNCJKEBfg3Qhre394c0i60mfP9YIgKTXrCX3Yt2eX
-6mPzYmLbSbV5jH69v6WZqYV2WAj-9DU0diR4h0fYQaJnBZhTtKb-SQsYiFuN1BDJ3v9eM9K
8hq91NBdCHVa-Thk9Dov-JkcTZnZGRRyW5yXHUV4N0ElTBXh8GkjJdvs5Yo3u-2rPCXjK1aG
PSI1W8BaUJLQY5sbfAVCAuUHBv-Vlh5Qamt-lgeKguhqTSuy-tjabOb5kiB0G7xGQt3z-XYX
tnWFDcii-5h11XfZsQ-xQxy8gSfdMz4hDK9NW_VQt6fzWiQY0Th_dHzVki0MUfVfsDUjgbLh
D6j0wgbS3zdj-GM3rtt8oit0wXx11bI0a0Kgf07tP0wimVXMRqRWe7LCUAKTE5PkRKU1x_h4
iusrzi5uwKDhc4SmRwm6KssNrmCAkiNDZCREVKd3yMnrjA4PAGDzdKWVplcHJ6jKmsrEzt
Hd9QAAAAAAAAAAAAAAAAABIFMEQ",
  "raw_to_be_signed": "65794a68624763694f694a4e54433145553045744e4451694
c43a72615751694f694a554e4868734e7a42544e3031554e6c706c63545a794f5659355
a6c424b52315a754e7a5a335a6d3559536a49784c576435627a424864545a76496e302e5
3585469674a6c7a494745675a4746755a3256796233567a49474a3163326c755a584e7a4
c43247636d396b627977675a323970626d63676233563049486c76645849675a4739766
36934",
  "raw_signature": "92723543ff422332c7e57cbde0a91ced654aa9970082d27798d7
f41948f5b8b03a6170161497d7921fb343152d125dd4202ef33c2894c0a4c347a66cb949
858fc0ad6ffe9a1fae2112537bc1e4bfd66e68902cbc1aa1cd2f696c7dc9421f76367f84
0d3fe0cb552d57b2e6e80c0ec3c378abd887582887d6272214ed138781ddb89eeba7d732
5bc5c2c90b610ab7633c474c19b9d70813d9e6e683f3617ab4cfe84fb0aa17a7d95e5589
2a80c98ef4ba3c48fff5618204b61dc1f2ff86b8fdb8f4a0d315128f8c84a62b868f0a49
e3b638a11ec415bf65de3d7c4a1316ad1e5e2a86c8a25becbe1095dad4a7f0e166292c0e
c1e3fe4876cfbe708266231edfeb1c4058a879aa8056ab540839a685bb3b00ada456dcd3
84bb34e17b0d449fce6023719c453646a7e5431b2c479b4025d387325a8d9bc4054e1747
db0dcdbae623f6982370e90835d232097808460783803187015162401b497530dd54fe4a
049868797572a7413465e3ad5e6bf0aad32e4700d838f6c285941720d3990f283bfca17
8049f25a732466effb2e8fcf33e5714da3c179dcff0ec531bdc543e5af0bc7f9302aec01
f7354e12357029c95293537ce1c75b49df89e54c82dc4ee8d7549568fdfd0365f531afa2
52098aafcb8cf52a5d300d0cde796a8a7216d431bce3e17021db00ddf8836520ef9d099
bcdff97e5ecd3b172aa0c6ee4dc807ebc92bdfb33e3dd8762bd59acd7509802ba981d2165
bc5a37ce8e64e2179f42ad5b5f56d2b6a83cc5e343843427eab4d3d09597b970de69d0ff
1aae3e14481f0708f87b35da90040796af0d30b1885d88cdfd96b4a403c98b458321667a
8a1824cf0ab1d70dd12344a61135aa88513e3895a625e5cddb2b4bfea338ca3eeeadcc48
646120b85d9dcb7a1105b66033384d261db84a3205ea8e83c98ceac620f89b5f78f02bcf
d0e5198c397b57a3c477bd77c1694750a0b79ecb2c0d604d2721cb25e33e5af3fbadc041
6255fd152b6a5dbe2ca238f5528b7cce3009aacfa805855cbc68c310396640100b93c83c
3b6561ba762c29b66ae0497668b56eb7235f52d991fb91e097448abfa452ee6213ae1ba7
43e0c928b882d1742f5b5d930bacd0eaec23a950e3bce9a415958774a51f77e56a54c3e5
7aa1b4919c79511594a6512201ee1d50d0899c891ce88cdf775e1c3baa9cc6cddcc310ed
ce3936b25da486fff4607432cbe787e2105b9a0b7f2c1c75db4835798e171de1c545f4df7
ad1e42f9659bac5f58d0fe793d7b3e17046ffa851b53352b9506c6251fcf8a52e479faa4

```

```

cff1d92f45fff16936847a14af6b33e583bfc4314230c4ebb7c6a188cc9f8e8e62879170a
37ae215b15418a89b9e24cb5eca45778b2970d2bf59c86564b46090f2b88e1e99fd7f092
641f1bd0869ca8b87405c86c6006b976e31fbf101d736d632126d8669bc0e22adfa7cca6
89cfc0a3bb5f87c02a60efa091a91b04cf6872284a5b6f83392904a3dc0b04342ae85664
39408bf72b65cd464bdee2f8c198feac5766fa19263f51e46f3c4940ed25200464ca6e7f
9cd1a62106e07ca653e145305ae79fdc16a0263666af175f9f74c92d26e21a1f67fe2b4c
d90b36c7c39e3df7c4fb9085a0c8cb3218202fca7101fe484eab04fbb428e0e4743c4888
dd9d1616d248d97e3b792c96c603e3e7468f203d541519e6033f6bec49784d258f78022b
4a098d6cad4acb980eb84d04aae7a09d6e12c30f547b20170fd91ccc8011a550ba08523
56e1f9bcabaff536fe332eeb43213ce600be9aea2ebe592e90448b3fe1552dc2be5c5d72
050c378755678670d8af43a5bdbab1143f872b82e8aaef3fc34e261a19f524b2e6fe4fb9
b0d3353c668392779a544e924bbfe218214025e82b1c1efba79d12c42aaa56d526b575c1
59b3954fe007d1de683bc17e1596ad401e7a45c44d8bd4b6622a84dcf630c43af4c3931a
fcea0324c0c9ba45dc8f17fab8f00549d5bafc429f3c3fb807ce17e76cd9e5cc3e20961ef
87895276f4ba5e626df8d3fad68afa72f940798bd4ca94caf17fde32d689336533db3f7f
efd7f5d7d2713b4532f3f7c100f7a7ae27b9771296c4aa4b3b9a1ea2d4524d9efbe533fb
b6f6c6286c9e8f513fa2d559509c5fc904044a133ef8a415e6d65e58e4ba35e6bb0895a4
078a750108ef1f1c21c8e7d2c07cabac378266a1d0ea2d8c245a28c42ffb1fac2e8bb6b6
d7aa9335a70d3dcd2aecfed4b5450f8b9d61ee3eb53928b0b3bf9dc92ab87c954fdc741a
307bf17e21bfd48b86d0d85304fb49a7c86d178a31d4b2b18c67d75fa30bc892bf37269a
b09453990303264863cd3c4251c3d903b218e8b677540794b55027efd4e08a159fb5a0b
f17824be041c6ac967e1ed84dd7fbdc49e61b0558c558e55da1c279e4d999469c9d3e0c4
1401c6c58d3aba04195ba0040658fd85656a5de87367aeebfbe3855e5a67e02e4f73e79e
bbc05870b97324984db1bc3a38c0ff34c6eb6351fb1e3f1e5890bc616355ec5aa4d9af5f
6d227c49596abc44b66c58f9adab9c19e6e70131ab022e938005e9d865d4807103610bbd
f02d2d19dacd47421068225ee5af5a77ef62d9b3f49ebb5bbff05a3b0e826a46929a3687
36fc950c9a7ed35194bccbcb3c607aaf11f2235b44fdb40f00c1357a1cb130c129a42bb
41f908843f2490b496b81bad5778d672879686cdfa1667d3a68d91bda5b6de85cab022bb
7e1128cfc9e4fab1f4abbce7d366bedf057c2952cdab4b806b94db1ee60fe1f024228a4f
1a68e4ce10f9178b2838b390dec119600d91d2fb783e6173d420134eeb6fc7c649e43299
09bca5beb64bc36e0b71bf2e271bcd2e97a5bf29e46ca042834d160d2995b15e36484cd6
b487a6a09f034224a11b160dd086b7b7f787348bad267cff582202935eb097dd8b76797f
ba98fcd898b6d26d5e631faf6fe9666a615d96023fbd0d4d1d891e2139f6106899c16614
ed29bf9242c62216e375043277bfd78cf4af21abdd4d05d08755af93864f43a2fff8991c4
d99d91914725b9c971d457834e125b415e1f069238c3bece58a37bbbedab3c25e32b56863
d22355bc05a5092d0639b1b7c054202e50706ff95961e506a6b7e96078a82e86a4d2bb2f
ad8da6ce6f992204e1bbc4642ddf3f97617b675850c28a2fb9875d577d9b10fb1431cbc8
127dd333e210caf4dc3f550b7a7f35a2418d1387f747cd5922d0c51f55fb0352381b9610
fa8f4c206ecd0f3763f86337aedb7ca22b74c17c75d5b20e68e2a07f4eed3f4c229955cc4
6a4567bb2c25002931393e444a535c7f8788aeb2bce2e6ec0a0e17384a64709ba2acb0da
e608092234364244454a777c8c9eb8c0e0f0060f374a595a6570727a8ca9abb1bac4ced1
ddf5000000000000000000000000000000121f3044",
  "raw_public_key": "ba71f9f64e11baeb58fa9c6fbb6e14e61f18643dab495b47539
a9166ca0198131c44f826bbd56e34e55db5e5e2d733485e39ea260fc6000c5ea4ba80d34
55cde53b46f34482aedfd5450fc2e1ba4f25d15f9c144242fb39bb52287189030c50498e
1717b7c758b190a6748ea9aa3f7acaaaf2c7cb526ed717c9f79aeb84214fa5cd8ded92a0c
3fa1558810f12c7050a367708d196cd24e5af974904aed8e4ce8872e8696b0b7bca50e45
2cd7d30ea9a4adac0311d672c6bde8496240b07431463708895cd9bafc31632d73976493
88fda6cfb7d305a3de9a495eca7433a8f83ba0f0b25c413c6e39c96eb7d691b34d37ce37
f1ead1cf217e25ef34eef3f7c60f84b8edfdde8405d4f832576c61ef98e0a2f28da187
700953924f686b94614705bcf53d33fedd4348edddbdf28b5065e1f20775043e85cf931f
829179363a1a7e7404a838ec00086b0976386fe637c98244757e3f769ddd4467471bfad6
70f9a05f8246ee50a7b1eaf87fc4069c3ae2aa2033258117792f0bcd49e083fd1bc7496a
bff29cc94e4868b21214ed316525399a610fbdd4a80e7c80715f29578e2a84bb40bddd4b
9f47a11b6e7da118a1b658d359e8aef55eb46b5376b5b655979984a922beebfc59bcd600
d5309dccd72dbf0787db8ba757b537c1eafd5c0f50ea4bc9583549e2829a42c28cac248c
96d78124c47159b18aed754aba17b19d430fb78f633ea9d26f54a9bd50f8d8f6b73594f
828976e7ea09c53bbb9f11a56c9507fb89b9a5ebc037a37267a95f85b8d64ca97192b10a

```

```
66f417b3f61fe9ca57130a48fd925eae2ab5502d571c8a51903c1d398f4c1f76a7e11743
976afdbc697f23094a3cd761ff9685de32e09fb3c28add453490300bc7c89dc017800960
71722945775f264e1b0623bcf4619c712c838761205d87691b75ef360196cbb9e9b92a0d
4c4ed62326e5024d77510b8ee2c7426cc22eae209dc9f13bde6bf08f5e7181bd3b459450
b451a51539a715c21d67dd330eb5970db00d9edbf2822b036fa13bafeb86d8dc78866e3
f8d43e53d78cca5595a6faf886b5dc112f1cf4adcfa875800d90b48883af97316fe15068
73fc157e570eachbfd222868d14234101966afb6bf9940829253a953ada89fc756b6a849f
70acb9838e69faa50bba75e3e89c2adb57e86d088ab9b04a28e670709172243ec5e0008a
5ceaf3f8722f487302596ffd755ad1b82a49c34b3469515b46aa290cd86ee38ea7a9be3f
103610335b531cca333ddfe32b14510f4b07ef95fc6684e8c454a92c10dbb5d59c7a7c63
fb305fe881967d99e669eb632840582560bb403431d40f75a4954908482278292821f4ea
91e42e78fa48caee3c836146dcfd738d117e92e9a15137d28e8e6a4b4622650cb413504c
b3a335d44beec5746c1c294b1e8cb99cb608d928f8ce3563632c521f23d13c61a8f61c01
df8c96c7360db4f3c68aa5d2fdd342a62ff3459c116389421ab43e8584c45882b50e6e4e
96db6f0b8fde890d5dbfadcd88690b449e64240ddb2023747f308363e301aa77757169fc
6150628d5920b5aa1ab1c8cbf44cb00e025d7879d72b479e3af5311c785725590da9c89b
9fc3b8450769554eb44d203eba2bbaef9cad2237011c2ea44eff00f299a48ffe28ca93dd
f85f76608242ef8d6cc24610a1e2078fcac4f9385c314905ecaa82e553916d94d1a7c1ec
652aa08897083daa2ebb1775fbc471ae27777d7904ea9f1b92bcac3d8a3158426087b645
b1108f0d65fec93789c053743ca14fd63d05e98b652df2b9c2ff9ce05f1940703ffb273f
80e0e2732eca9960d981b4cfd3b7bb8045b3c3830546b9dd8db0d"
}
```

Figure 3: ML\_DSA\_44



```

li4muZ5KVvfQf_5hza1V4GweqvmeWuZL1gBU2HPS7x1tWL798ALOk1rMnxsvB0PiSLxAEdPo
Iuw0_qmLkjtavJcDFaihGcgGMUk5SjU65IWQS9t4rgxv9Idu00Csozo9iCBqrVcna0wUpkMh
V6KeiXA7kQncgVaMio40cjSyMiEkHGIOE0f8L6eoh0h_bPPRYs-8NrZ-V0BJCa0ubJcDU1c
TuGNca7nWWxAqfVjcMyNDx9XHBVbnSocFnfMFP7S9nvqw3KC50U_t2PH5Sfws9w4DLvcgrlEP
_gwSgOXuf-i0tRGLQly3IMB708QonkofyFaCUDZeurFkGTpoBft6lzbJznQAMIDPNcWUsRlN
TXsH7atC1nx14xDJLmmPLCxiErFxbCW5gMWox0kLDwfsFj57hsXG75cZ4jiBbq9b0VjD7Vkf
8x1c06ExdzBhGXz8oJiaT5WHDsuzGtrFmh6diN1c04Cxcjr6KdNE8IlyxsfXxQ4AI-0ke3gMy
i0D0GeHgHuNc-JHD7oZ6njUMSTBKR1aUMNT7n_2nfFTDCdqW1HaMsMwIHfL0k6dayKXE1oMq
Y50p8S5k_SAaknR0vNxmhlTA5h3bZJ28NZxM6R7D00_eBEYrH20rmRP7G7kXKzLvmWeaKAh4
oQHihqjVhgauiePDRiMmjx0hdQnMCt08PWbx06SiviRn_5hswdVV08B48MVHqbM2AxCLLJYi
n2Ep0302Uo0DI-rTNZ1Znn58kM7VCskcxDLsh9AYvPz-HQR3H7Xg0ElwjYn-jJXgZ_cdnLF
t4_TuKQdpw_qhvyrNj0x0Mdc-1PrwoWqpA9sSv_pS5lwi2qNVHI2Vj2mZHByod1QUe0QExf3
SBjP_FHEAUzUu10K8M-1SQZGzJT2su3a6ZnMnp0U5qdXyMONFoI2jJ2hdjt7QEQLx-rvaLx
ZMJtc2z0MHdwJGAC_kug7XjH3SWQZzBu7zzreIaSwr2A2oobeZiAydw8LX2QsY9Jr_NphGA
MAqzrpkuamYbd_pFTKmp9s0GYxwyG1ZD9uRuPI9imA4CS7bt-08YvbWg6eQ-qa90qDlxNt3X
c32TniQFVxVxN6PDY33XXU-Rpvd1w47NZ48nkyJzjD8Xl1bvk9p2ynxWHR-Sto5HXZdru4j8E
TUW7ri3mEG1m_dxAbAe2kVbsBp2I1vQppugbmRexuMRLdYFIKqNm0qpQoWTr_k2t5KHnWo1r
SbFH7Usm8Pwyi4sNhh4_yRHAD02q2o19zCCx2p1DSMeYI74CQPRGL1K_GLM4E5Bzfny3E2ea
E5_gQBTSGNHpQtJB0ipPwDjqsJDCXqXupCkRta1vxng4coi2-vWYvKu6mq9HhdovHAAwRZry
vuPPI4ZDN_NkmfQR8HogR6NLVhLlRp1cwMARSSDA3f8Ql1nJdbaeutxRXvFnCCjBk79ws8VgD
WAuRmIWgoFEfEVAVxkKjJ07z0W8I3kNfB6pnxsZmJwWAGqWc1U1PmkNBstmSXinAzbd1-W-km
1XRDUhzTafHnkCbKS5XgJKsWD2F rhcnCaxxRxsuIGxijofjD4ihmJoYDFh1FYs9IcC-szaEfM
SekanWOIZChd1fVzTSbLr5bNa0XR2s01muFX7w22m8pBVD3fyOHK2JnK4FBCnEBrruMIDaqq
u8Z4xesAHKfxY67w-25eUuvVCGl3xpXSp90684ICkG4STztP1shLVsxKDA-37sKkPlqemER
lMPY4vDM1Np8JlVawbSGIuom20g6p2KV_zpIPwx9vd1nAiaeZbryf3N5gtL-d0q-c6uZhtCx
90LbtLGE3BcAmn5JfJMGQFxyTL07BluNu24Kf-lttGj9jzbpZYrok-SnMilXGFEqB3D3cKC
0lWjsgg_3cUW1uMp4KlWQvkmV9Pd7cY70w607jcyBJ3MlFZ8EeWeYPZ9qu6xwidA8X1LHxX
xfLIJ0gFpU8MTppfxdnMhqNSvH_Hx57oDphbUks5K1Z8-04dSnNqQ-ZWbhaAydYQFDKuUF6H
YTAvaWhJmACxhTkT2t6-P3bev-FcdFidszJC9LxWtJ96LY_GV4Qvp0hiIdyP1BukWNHtsXK
2Rxsres3_4Cndg2B0GxVcKZ9YpQDCUy76GRbTCenqjD-SG5sVUEVha5yxbKArPr2-Xpgk8cuZ
BRsAdmPNRdxCGutldfCLEl7xhJvryMouxqF75PmbaImHcsMd95075ePt_VkClUaUj55Y9E81
Fb0EchPfud2w3TtSvRPvB8-RgY8sLJUAcLxcUGE4PnKszJ7TIBUtHD6uyZ0-nC5KgbXZsBE
zUeHns4ix0Wmo6-6vAM4PGK3qRA1VAhtKXyvNcAfVccVi8KJMK9Mz2eIOXPATvyRy34Ltrcg
8tcgK0ftYqEWYpAZ2fVpZBxcYfTIinuLN0-qLra388EZuu59jvmRD7mUv1msMwVMGveBoNP3
lJaJGGWk8iYyu4q7Grq-6Wxr5qCz_7kwAtVJdb-zW8U3jLJ3tRSYlyjlpzeVAGjDQ6Yni5y9
x4BF-5QUqcoGMLLglyx2WOCELT8IW7nsV21QnqqAbtCzZ76UtEdmUuE0TyqiKQZ0lrmRm3Y
rCvJKxtR5thhTRka708NzBvwsRS-JxGG_EWjHhT-aB4VL3IL_oz3mt3iQoszfA-SzHcKU1l
aZMBuUCyxs6KiJgQGZRPXyaxxDtqZdarP8Ic5CmuPeyu3kafi0L6LFijsUxnSGxTpgu7hfv
cmowQijfE9_ylvG8k_EbI2miG11giODVCyB7k9Yjyriwc9dSUUZ7Xois24hWYUX6BGGQNN3w
VHPKDKOVSDBYTjt099ulquryx4K_UMCu9sQVNXBfMh8tLN709-MXlnJbHfKfqFHiPGdIYOBP
wuqJdAJiyiuSG3gJxMG_wuwNkBW0--i0m6PIarCylvL8_P-tuUft4zIgjJJ3o6YJhbo-q2K8
2ZFmHuILyzfDSgtHDZpZIR7XnrQWet90cJEHL5k653kvyEHJg0iUiE0iwNA5d_4gBq3vmw1J
74hwaHx0Z_iYEcPS6hdGow8M8D7UJTZdKuV_86zj2YqGm_QC_aAeD__NP6sa61bI9-gT0zvY
c0JiExKTDj0K9fIvHaV-HN4xr2vWner8o6jPyETvGM8D7aEezlUVOEFwALmhJPSMAq_Fk9Jl
cIUuC-ITJZNtNz9Awfiru3wkPja1bXN76WAuRHjia0x5ptgMCy2py_vSHZybfIS85Zjs0Q-i
_e_niBzhyzXwzBaLEyEitbF4ZQx5c88lXKDMpe9tirAI6XAcqLf4UZkd8Wm2YV7hVfxLQ1A
WLEkWE9DZljctE-SbS1EWNGR8faXKcvaZznRyoqdWz8IN3w7KvaA_ZrEkkIXkkreztG6pI06
DLDHCl_sU6rCOoyQf6y1AY770b4SdksRoBHGGR6Uv-LrxHpyJ6trzcCu0kqxubHrkW2yHcqe
6enVf43zYwWkUeJJZ10bt3a92ziSne-3aj6v3guiKoJoLnV_9h8rUF6zorTWE-Tq58tYfb5S
mGf4iCJ5cy9LTY0C0IfwJtPkUmyBCZwUhWJnV24P5p0ZPe_CckQ28xv5J7Zf4Bvqrq_rhubF
EhtJ5JvdMfz8Whc56WSHX7GRKEMqXVp3pHohBv0yT9BmotzIlibVk1Jy4gzkzUcjJJ0ld-B0
aM_cnMiHpoyKXSJAXTNwXngzEpbvDP2Y0fnrgqDp03RR3gINaZLRmeG0WI4wWBMMfw8PHjpy
V17C_1hmfRI-darbZcX7PD3N4Rw4lBACyk_wn0HBcAS-5cLZEzNmFmhc4i04msz_seQ1N0dr
bB0NoUUVWbmcY3pGC9TiY6f6Pn-FBUnQkuBhIyPtgAAAAAAAAAABgwVHCuv",
"raw_to_be_signed": "65794a68624763694f694a4e54433145553045744e6a55694
c434a72615751694f694a5464576c314d6a6c78596d5a3159554a68556a524264484d745
97a5a5955554a6c55454a66543342426545463359315253587a424c57465a4e496e302e5
3585469674a6c7a494745675a4746755a3256796233567a49474a3163326c755a584e7a4

```

```
c434247636d396b627977675a323970626d63676233563049486c76645849675a4739766
36934",
"raw_signature": "ce63bdf46cb80901e82854dca67d1a389c63cae6556d4851a70
dbcdfcd8003e665045e9681520e22b6f67cac05198b81cb6f9f50a83412052a4c5c2d1ac
5a8d738c57f62db5f9b01a00ba14cc9a311664c7e03dd9b1a234bbada97f6373044b26a5
e3324506873d98a477bf995f50a71a244421fd2ba8e4c85669e21648c055e146dd73d0e1
886b9acea072acc4e0805198535ca88049bdef93d9540125b4f98e7c58a4f8ad59acb7bf
ddbe4ec555b7bd03d236d481fe4ea960d7348ca08f28ce1d5a0521bddae3eeaec05de4a4
5c3a527084d51824380749c2075cce87ce4eaeaf7c5b9a2b28f1eed6b0c82bbac7248e19a
ee8b8c018e640bb0f134d4b7191d1c78cdec43093302192a236cbd45893f42537a147a9e
2858ecad4c401fd9e0a2dea0c3d224aba7922c942b9ea0d8ed18e1529d42a5b2709e8991
7eb4da93cb52a927712b4da34f702cc2bec11a96127015aec90384254cdc2da3d8f
d5105c1c097d469386c423ed6b2c38b266a917827cbe536a119e5974777bbe7b64bf460f
bf78bd47fd711b3ecfe49bef36d86ec963d962e26b99e4a56f7d07ffe61cdad55e06c1ea
af99e5ae64bd60054d873d2ef1d6d58befdf002ce935acc9f1b2f04e3e248bc4011d3e82
2ec34fea3252a34dabc970315a8a18028063149394a353ae485904bdb78ae0c6fff4876ed
0e0aca33a3d88206aad572768ec14a6432157a29e89703b91035c7a055a322a38d1c8d2c
8c88492118838439fff0be9ea213a1fdb3cf458b3ef0dad9f953812426b4b9b25c0d4d5c4
ee18d09aee7596c40a9f56370cc8d0f1f571c16019d239c14d7cc3fb4bd9efab0dca0b9d
14fedd8f1f949fc12f70e032ef720ae510ffe0c1280e5ee7fe8b4b5118b425cb720c07b3
bc40e9e4a1fc8568250365ebab164193a6805f4fa9736c9ce74003080cf35c594b1194d4
d7b07edab42d67c65e310c92e698f2c2c6212b7f16c25b980c5a8c7490b0f07ec163e7b8
6c5c6ef9719e238816eaf5bd158c3ed591ff3195cd3a131773061197cfca0989a4f95870
ecbb31adac59a1e9d88dd5c3b80b18ebe8a74d13c225cb1b1f5f1438008fb491ede03328
b40ce19e1e01ee35cf891c3ee867a9e350c49306447569430d4fb9ffda77c54c309da96d
4768cb0cc081df2ce93a75ac8a5c4d6832a6393a9f12e64fd201a927474bc668654c0e
61ddb649dbc359c4ce91ec3d34fde04462b1f6d2b9913fb1bb9172b32ef99679a280878a
101e2aa356181aba278f0d188c9a3c743a17509cc0ad3bc3d66f1d3a4a2be2467ff986cc
1d555d3c078f0c547a9b33603108b2c96229c2d84a74df4d94a340c8fab4cd6756679f9f
2433b542b247310cbb07f4062f3f3f8742bdc7ed7834125c23627fa3257819fdc7672c5b
78fd3b8a41da70fea86fcab3633b1d0c75cfb53ebc285aaa40f6c4affe94b9970236a8d5
47236563da6647072a1dd5051e3901317f74818cfff51c4014cd4bb538af0c9fb5490646c
c94f6b2eddae999cc9e9d14e6a757c8c38d1682368c9da10e3b7b40442c2f1fabbd2f16
4c26d736cf4307770246002fe4ba0ed78c7dd259067306eef3ceb788692c2bd80da8a1b7
99880c9dc1bf0b5f642c63d26bfcda61180300ab3ae992e68cc8177fa454ca329f6cd066
31c321b5643f6e46e3c8f62980e024bb6edf8ef18bdb5a0e9e43ea9af4ea8397136ddd77
37d939e240557157137a3c3637dd75d4f91a6f775c38ecd678f279322738c3f1795bbe4f
69db29f1587afe4ada391d765daeee23f044d45bbae2de6106d66fddc406c07b69156ec0
69d88d6f429a6e81b9917b1b8c44b7581482aa366d2aa50a164ebfe4dade4a1e75a896b4
9b147ed4b26f0fc328b8b0d861e3fc911c00cedaada8d7dcc20b1da994348c79823be024
0f4462e52bf18b3381390737e7cb713679a139fe04014d218d1e942d241d22a4fc038eab
230c25ea5eea42911b5ad6fc678387288b6faf598bcabba9aaf4785da2f1c0696ad9472b
ee3cf23864337f36499f411f07a2047a34b5612e5469d5cc0c02b4920c0ddff109678dd6
da7aeb71457bc59c20a3064efdc2cf1519d580b919885a0a0415e5405719098c9d3bcce5
bc23790d7c1ea99f1b19989c16006a967355253e690d06cb664978a70336dd97e5be927d
57443ba1cd369f1e79026ca4b95e024ab160f616b85c9c26b1c51c6ec481b18a3a1f8c3e
22866268603161d4562cf48702faccc47cc49e91a9d63886421ddd5f5734d26cbaf96cd6
8e5d1dac3b59ae157ef0db69bca41543ddfc8e1cad899cae050429c406baee3080daaaab
bc678c5eb001ca7f163aef0fb6e5e52ebd50862f7c695d2ca9f74ebce080a41b8493ced3
f5b212d5b3128303edfbb0a2a996a7a611194c3d8e2f0ccd4da7c26555ac1b48622ea26d
b483aa76295ff3a483f0c7dbddd6702269e65baf27f737982d2fe74eabe73ab998530b1f
4e2c1b4b184dc17009a7e49163306405c724cbd3b065b8dbb6e0a7fe96db468fd8f36f03
d962ba24f929cc8a55c6144a81dc3ddc2823a55a3b2083fddc516d6e329e0a95642f9229
95f4f77b718ef4c3ad3b8dc601277325159f047967983d9f6abbac7089d03c5e52c7c57c
5f2c824e81fa54f0c4e9a5fc5d9cc86a352bc7fc7c79ee80e985b524b392b567cf8ee1d4
a736a43e6566e1680c9d6101432ae505e8761302f6968499800b1853913a76b7af8fddb7
aff8571d14876ccc90bd2f15ad27de8b63f195e10be9d218887723f506e916347b6c5cad
91c6b7acdf029dd83604e1b155c299f58a500c2532efa1916d309e9ea8c3f921b9b155
```

```
045616b9cb16ca02b3ebdbe5e9824f1cb990514807663cd45dc42814b6575f08b78bef18
49bebc8ca2ec5f43be4f30168898772c31df79d3be5e3edfd59029546948f9e58f44f351
5b3847213dfb9ddb0dd3b52bd13ef07cf91818f2c2c9500725c5c5061383e7292649ed32
0152d1c3eaec99d3e9c2e4a1b16d766c044cd47879ece22c745a6a3afbabc03383c62b7a
9103554086d297caf35c01f55c7158bc28930af4ccf67883973c04efc91cb7e0bb6b720f
2d7202b47ed62a116629019d9f5696415dc61f4c88a7b8b374faa2eb6b7f3c119baee7d8
ef9910fb994bf59ac31654c195781a0d3f794968918658af22632bb8abb1ababee965ebe
6a0b3ffb93002d54975bfb35bc5378cb277b514989728e5a737950068c343a6278b9cbdc
78045fb9414a9ca0630b2e0972c7658e0842d3f085bb9ec576d509eaa806ed0b367be94b
4476652e10e4f2aa229067496b8cc466dd8ac2bc92b1b51e6d8614d191aef4f0dcc1bf04
91b3e271186fff1168c7853f9a07854bdc82ffa33de6b77890a2ccdf03e4b31dc294d656
99301b940b2c64b3a2a22604066513d7c9ac710eda9975a44ff087390a6b8f7b2bb791a7
e2d0be8b1628ec5319d21b14e982eee17ef726a304228df13dff296f83c93f11b2369a21
b5d6088e0d50986fb93d623cab8b073d75251467b5e8892db88566145fa04619034ddf05
473e40e43954830584e3b68f7dba5aaef2c782bf50c0aef6c41537105f321f2d2cdecef
7e31796725b1df29fa851e23c674860e069c2ea89740262ca2b921b7809c4c1bfc2ec0d9
015a83befa23a6e8f21aac2caf2fcfcffadb947d3e332208c9277a3a60985ba3eab62bcd
991661ee20bcb37c3486b470d9a59211ed79d14167adf747091072f993ae7792fc841c98
34894884d22c0d03977fe2006adef9b0d49ef8870007c7467f89811c3d2ea10c6a30f0cf
03ed425364391457ff3ace3d98a869bf402fda01e0ffffcd3fab1aeb56c8f7e8133b3bd87
342621312930e338af5f22f1da57e1cde31af6bd69deafca3a8cfc844ef18cf03eda11ec
e551538417000b9a124f48c02afc593d26570852e0be21325936d373f40c1f8abbb7c243
e36b56d737be9602e4478e26b4c79a6d80c0b2da9cbfbd21d9c9b7c84bce598ec390fa2f
defe7881ce1cb35f0cc168b132122b5b178650c7973cf255ca0cca5ef6d8ab008e9701ca
8b7f8519903f169b6615ee18557f12d0d4058b7a4584f436658c2b44f926d2d4458d191f
1f697282bda6739d1ca8a9d5b3f08377c3b2af680fd9ac42a4217924adeced1baa48d3a0
e50c70a5fec53aac23a8c907facb5018efb39be12764491a011c6811e94bfe2ebc47a722
7ab6bcdc72ed24ab1b9b1eb916db21dca9ee9e9d57f8df363058a51e249675d1bb776bdd
b38929defb76a3eafde0ba22a82682e757ff61f2b505eb3a2b4d613e4eae7cb587dbe529
867f8882279732f4b4d8d023887f026d3e4526c81099c14856267576e0fe693993defc27
24436f31bf927b65fe01beaaefeb86e6c51214c9e49bddd31fcfc5a1739e964875fb1912
8432a5d5a77a47a2106f3b24fd066a2dcc89626d5925272e20ce4cd47232493a577e04e6
8cfdc9cc887a68c8a5d22405d33705e78331296ef0cfd98d1f9eb82a0e93b7451de020d6
992d199e1b4588e3058130c7f0f0f1e3a72575ec2ff58667d123e75aad65c5fb3c3dcde
11c38941002ca4ff09ce1c17004bee5c2d913336616685ce223b89accffb1e43537476b6
c1d0da14556066718de9182f53898e9fe8f9fe141527424b81848c8fb6000000000000
00060c151c252f",
"raw_public_key": "424b2f267e58d5b3b44d71acfc6a656bb26950d57c61db1c880
bcfa1feab443f0942ab8bdbad7d708abbcb356078f6d99a252271fe62c74091eb94afb9b9
264c50a888e0dfd80cd5fb2cbd3667e60d539ebe44930219cd4faed15dbb3455a264802
b9f49bce42ee7550fefdd4642a55ade693868a460cbec03f4fc99a4e30bccffa8a475e5
395396674ebb81a94937587880f6dbd27bf1c4f5a9ee43cdd8b0e53b3b7fb49c73adfbcb2
d4f8c54303520c29bf97e26ee57db342d957c893936522d0942b41d82ee3772a00570adf
b545c1143922b0496f826a0a970064b36ddf534b5f8e1c1cd0b5565ea846b45431f06181
43ece89777bb3f61179ad20295fe0a6e062ae6eeecbc2ef38f2ac1a22dc93b7b126336223
c55b61eb8c0795542bbb2dc65e722eadc6866ffa9683beb8a999ad7a83e5e6e016c2e4c3
5f6f7649ad3bd52ec67ec1c5c6e7b9972771218be9554bba7727f0b84c44b9b0a8bd831f
cff2c9779ccd4ca30c6ad75b04983e41de893ee5f39ea7355180b709c7045c22d33a083f
6ae07a114746d1bffdccbee5b9043879bb5a2e120e2a4636283f4a1cd4924a2de6a4aa3d9
9ddd88f48aaa4e88bfd1ea769d82c10779f2ded796db542971ca289b76863ede5997b7e9
ce183b43ccce278b10d92b87442ce0435bb1625171db5554b470239c50d2a0c3a41b2a38
807db070b47bfb3e7d10f3cd979d69963c8d79f8029cc4a48eb04fcb3d708844febaa8b6
ddf01ab64d59358e6505c4ec1d7cbb14ed2212df458ecfc03fe03037b1505a4c944432
2f5f98dfa91a4cb8c45860a2dad7515350bb6d431e49a6bc8f5ba956e682b0e513321a9
7d1962602891c9078f62a8a9646a31387a6f09684264837899e0d8ec7d11c565901298b2
0b345081690eb4c562c1aa3a25bef06566cb34c79bc0b25e4095d6ba793e81311e41a332
9152686f00d4897f84fc4edf4b26d545365785ead8d63aef64a87c0b91a2e5500383956c
df5f6e37cf9d5482d1c8e3a5be38f17259ac45c9fa1c4bd3bf177d312ee52a6da023c057
```

```
22a8738274dda8d1b04e99831cf57c87282a256c565c296d0524a063a3a41a48a8300997
8d98d8abf61af68e8013b594fe151d9bec199902c4c70b49584201743c6b53103d2fd24b
df078dc90b5a188b4f8d772179988d0416c94d4c57c0860b9d7b53d4cd261f332a185156
5d52ac37f008747cafe320f363d9beb6e4117db43fd8aeebe5e0ce2f54e3f0367eb3cc97
1bbe0c301a8e52f96094936035c6ee3ca2d13db483a0dd04dc16247de0e0894ad7cb7e1a
e7ebd4f8f900582b20021e77f70254501c6ac3dd15d43bbb7931c5283244312158c2eb1b
3e1117e194f0a1e4c783efbc62c9f81c21562d0d34a5f042b5eaa32f31f95c5b055f4e7
a2070fb096f56c415549cde74f3864e8b9fc27e3299724b4639986044b55928fd6972785
b280c25a3e21aab814ecbfb0c3cbec0914907ec907f25a1d88bce3d319ae8222a35945db
62af7cc75cd29c1f5d98fcb93f750dc3031076979bb51dfc37d23e8eea78073a24d3e26c
68e7bb10e459f2577b90080359ae0aec10318dcd9e0f9e34029c31b3e54b1855645db420
618783346dad5b55eddb4f977b326a655525ebe2195eca9cec38a3c0d2273b77d3e68f19
01c2ca5149734a51177bcb089476b18cba09fa8b9b46d94a2946f358e1dec1998652c58
a90852423e2c85e79d19724461627e6390d1a81fb1a72f9c7edc4bd747dd5c85217b5856
141028414ddb71458f0a0b2b589df2e1b051783b8f718676b1defbae98ba496c2a935e9
2eeadea0a8393ef59f9e914f0743fe65640ddf9981cea6dbdd957a534ad4e790efc974ee
89938ad99d53c5b680775399326834729bb37b082e795f8d87f52e6c8a8db68e515c277b
bea82a7570d4280896c987a0608903e306c632a223c55f0ea3682039c4a3f5440f4b5ac3
e6ed2b2dc900cecc72b72f50e49b2629ad30f0487b2707b86286f8c4f55659b25f9bdd7a
6af460cc3c57a3982663bb717461581e196894929d84153d87a7f482d284b5b894ce1a78
216b2a011f2b88742cee52d5133e8fe77edae242f5af91637c37ffca32430509b2fe4756
303a9a3659fe32528af1e10d8d43bea991b2d109786cc66d35b1d78df254b92cdaa40f91
a987e4a922ca81050e5bc3530ca85493bdf2a825374d0a8310a6860284ec3ec732326eee
ffc42bbd42bc91b73e5e7c6b599d016490637629f3876c3e42f8db590e66a85a7838c818
f78fffb4853cbef09434989803545dca87657cf7c7e7e6afa71382bc10fa0bb6480f243e
ea1b861101006fa0cff3275621943cc58eb4dc3a0428a5e425670fe82268de71c511d8ff
bdc11b0d0f961120e971015ad5f448886b802e3fac11672319d487c84f1001339cb96978
4cb57344f2807f8b425f1d73caf8496d742ed237f4c9fcd5a4e84fba7e27fb1a8ae12c4f
0427ae24e910d951bd8c35d61f8a678db01caea8ef789a95b62ee1b8c5d32c6baa536ba8
8a1070ea61aabbf59294e3f6f974c4c91cafc5bbf6b7ecfd57a18fb7557d71e06e900d28
1b0b49aa00feabb35714af33870edd7ac2393d93177f79ee5606c9df176f025ce49a6e5f
f51a2a412ebf86ac0f40471c96ad4c119df230be6173df530ed656cbd8069214741ecdd0
271c603fb6c4a8614ff878d33e726cac6693e938ca3fba82c4995c14a2d4af9014fe4c4c
50b794cac596b52189f66a7106fb325b526ea"
}
```

Figure 4: ML\_DSA\_65



```

"priv": "AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA"
},
"jws": "eyJhbGciOiJIJNTNC1EU0EtODciLCJraWQiOiJ0Um4xSk5Ja2dNc0FCVlFCBFlhRE
h4QUljY2xoLTJJWDBVZERFelB0NVhVIn0.SXTigJlZlGEgZGFuZ2Vyb3VzIGJ1c2luZXNzLC
BGcm9kbywgZ29pbmcb3V0IHlvdXIgZG9vci4.hmMrKkUgZwGPQV_WUoXUVq_Z9W0enDZbfM
mHpKritl0btWi29TC8eIyQyT1FAuW2kg3h6ALsvCrjX5tn3QKFQZYC0sBdRt0VNiDm0BjyJ4
jWcomSCgb0-cGXaLl0DAz-njGridYf01DpGMwHHshuKuvECv4qnX3XgZPE-6C8La43TZrY08
brzBXGiuYgMLq-TSmXav0eiatdtp6iTUqJDBgQSYvPB6PvipeCP1QH2ZQi8qkraxspi0lgy8
Jh2aRYj44DX2ZKq-Ml-hfBjB4iHRpWmwPpEH7Ed4LkBIlaqZoPccrPgpGQpyz4_FcahrJc8C
GGtT05I34o5BcuZeJ7W0QvJ6mRmvYqIrYwoLs-3_YFZkVdX4KU38oprMvAHj0b0hy_vZZArM
nCGfYlCKrAnbh0ZG800BXgqow5Bqv_oRIZtGQZMrivp_1CS0hELarwkjdyH5R747ndV26I
Qkeyn6y9daXRZIWxaC9KmaAdSm5-YsRvPiAAR0Qmfav51z065_r5qZmOMFIBERVi9Bbm_Z7i
pJkoIL2SuqVsePATfHeWB8huFpVFxdeEKJUPDuBtthax0HhxpRuECpFNJf2xA70Hp5C5VZIsi
5E021HuRpixiNKmXP5whhsn_uv_B7R4f4DX6X6A531FrUfPFIrTfOQvBAvmEUUTSGcPeT-F7
f_1lz34uFyN3ZT4FCeCh4n4yyZY1fSPVMnt0fK8GrLrRoWdi8gMk30oTKgb9zFkFU7uZhVEV
RV86A_060bgFSHWDz5d1XLfyCoJsbsHl09WBibTcKrv6lnjh4czprro2prRtJAJB2jVwS1d
v2mo4wP1lFYqY63yM9I9deU4fxy6mkwig7XwcVJskg8jX_0agATqmrKfYWMI4yGQ9fciYacg
N8X2uSHqiPU1cgQ8VUGsSAsw4P0dZpmcUt_DacVLT8-qwnq6NWpm8bqm_uUQu3JjqcHKLz7z
WKopelG_ZY7a45IqUQpwbMg9ICE1ZNTe5nsMHAJnevgLfwk14wnvVQyRVv1SvatdUTg0EjBc
6P35a4lY12vI0q2ENpA-m52TfXeXxXK0vtZft9SY33thi4EfZABWL_jQyio06b6AKrh6_PgQ
-bh2H2Fpu8Z3GIImrbHodcbnqFpmKYlMLwXDHnKpY7PpyyV8HsWfEjqVlAX56stAIIG4_oww
zMZMcFwgucAP176TwaXJqm9v2-DXisD2cNjyG1J_rec670rv61thjiJF2uZrB9Z2zoQVYnc
3Y9sJMMPPmunUcXpNVZWSsPlFD0Pa1ABoFnRbP8r0-qbNGP5N7xY2DuPRY0P3CdyxeyDPmGB
C2556FNeLrj-PhPAkd61fgXsQZyS9N2jHmFUIKbL8o-e3bQnqW7ebEn7zAjS_LQ2DtGIdIne
Uu84hh8AduoW9ky_a0pqvBUmdnHUZHQiSSdeCPNe0ssVBbuDd3gbcQf_VWvplwcjTTrJPsq
qZpirjfvGPFUCVAz6kD0vhFcvTdt6DGqys61xg_V0fj6wpxKsXuXDuqwaeb4KpGniHx-23n
ECgKG86N_1BBX8RRAvYnksxIIXIxygrng-y44CV9FL_wGfP0Plx6JjSUFOL1gDZTc5NrAPo0
ztEo1FbJ2Lq8gqBR9Ku9Yza3aYANAjQvAraTXzA0t1j6qcmh-WtXeI1GE-8ne0Jt1RVbzT5R
vPiRZAVmu9PpG97wbLLQNPJoqIYp-c9mieGsDxAi75C2M1ArRnCa4kJJXrupgzQzzFefWyaR
kIvC2MP9MwB_Z_NY3mp3opcNlT1TdKlR1sncLUkk3qJ0Pwyr-5dsKrC6aenapBH07G00nA0q
T18-0y91VqjYYcVjc0UQaxNeMtnk-pLJL7j3MzGfNiDkc-OfR19fcWvDmmd9Z8wtj20khL4mT
Dn7qTUo-PsVR7GnpqkImmEmE8sa4ZlPHa4_IcZGFbdcpw9xuOndINlzWGrIKyWFPQ1x26zXD
Ea7f0x5f01ax8dIU_KWNAGdaZxPILqLW5qbC6dipSqf9Nwb1ZLJs5DCiLV8nHS-QM26xQJVU
NH22n_3Z_8z1SA8AX8d7j0-g1Pf7NZC8e8Ipnm4B3YGpA7nn471aTbJb40Uamfgys17MV_hP
DK_f7FF7NXp06-dtVYDmcs-87ZkrDuluOkUaRivKULwjEtSbiiKZAKirGfA0uwYCbbyzEpq
YvEztABSmDYd_F_autklob_0deKuvvRYfVcaxeaYQ7WIkpFbBmXeh9Qci7kPfgyB5H9ajWE
JV3fgRk10Q1RaWyTUddQ_jWaluiDa3GD_t39sUrG7QhXc20z1NPPNoY6-A4jFbFctXSF1muz
tqy0xaworcNiHY18yeL4Cw2iYLJ1Q304NnFo3E-wIXmYF4CLxZifr2Jkd6Ix1w-wlsN6vyCc
Ds8JeAgeJn0_0ahk1mgvRhVz8FFeidSdFqJbXGkbFZ32F_auJwrsLyjN_ShxTSFofyKQy2XC
foVMko4eu5o6md66xBmjZvTvItXL7f-eD0JxISBsBkZG3mFrApZKbdpI11Ea681ZbCxRTYpx
UR7McTbs0Q5S9PCN5E1Uz_axfeupIIBCTE4S0-ZQuIdQcQ2pn1j-4t2c04jtLE6WFI-1ASBC
ed1ZmrZUiRegbezE01hMiFnfn32BhBu7ZcnlBCdWwj9hUfPEduJIgaA3acXhysGs40nqRzR9
imvX9CBQYJZjrChr-wORF6svmvF5FADRgwbM7Cc9puJgLBiQwXrhD43B6kXj_0Xi502UNZFk
APr0WONBjsip8CgR6pt1u_mIKlIrYM9Km-idJGGT0DZ9UU4LMx0-9_2KCKjDqgYN1rS9DA_
_GP9tS3dJ-XLSlk2URQuoHm4Xubv4vwgJUS7JzAxcQWHB0HtHfoZ3-tYVw_GRbRwy0Dm3E-N
503L_R-pva9fv1PjkCNMrf2IlxAXBKML1gCxsSqhFr5yoPeW40LTxMF_dYPNLjC317mRR1_w
fY_FhvoyI7hrGcyfMgWeb-cYyx5eXumt9lMFOD3dQtEG1IUbde7pVXG-barWK0Zl43DtQMNQ
zoCK_BLxfCsambyRRcI6E4QTfqe5lWtVf8Wi4KproenWyCjjzEjJQdWw4g-ae_bjGjFZCp38
RgsXtWgI_tuzKyRF5WwjyN9VEoRXd8W2DctmBejHF2XDYZbMFkJ-384SokPX6intnlqBGMs0
ssxriJhsFOA-vgDra6REx3DUMb8_u_Umc-zp4E6isX4D-eRYgElmj0ez945nqxp3Yli08mRL
MW6E40upLthfw4vmK3YqTAuXcnGxYr7JqAkMfz5uAPi0SqPwDQZq7ycu9BmkMXAIhMb19XB
DjL7hZGDwDRrn9yBBcYlPaFPNXjMJWJH_xxUKNsTFGg5-J_WdxXi8Zn6tDMxbxqqjIpw_FUa
M00jJ2MhpbkzhEx7X85pBR47ScRgr6WJpf4ZLSFuV7NT1WI3PIBa_bYeCiq29f3ShM-1bRF
dJG_1GZd97TuAMF_QU6-KDXBv5i8kUZ1NXdJUz-YaA0RRVNFgMGM5n0pKB5IFncAPK-taTzH
LIZJ9uuBdP2y2Hxwbw8YQlmy2-MT5XE5Ae_9kxuvI1lSzjpfLN9012HSnX4tZ8x3aWwof3E7
s3jjzw7qbBtoUkYYpIGVOKf2EpmHEqevS1XYWpBYN3X2ZYjsrA9CL9PTvrPdyWLwKBmfh7cd
JbjNXJSQLeKL7oHzicr1lABzR9Ckkz7b24XGV1Klcat_Og4oB9qxi02zJZWz2GDTAL0hosU1
HLWnrQYvqFzddIOzGlfwIyGgoRnb44IRMzssErxuoqkdjZewVc4PzruHRLV3cWK6M7ZUiWL

```

```

txtMzas2sfaERY8BdS7ISLzj5PERoWyYXSW-898WD3ze5MJcpSsAYNEmPCBtdxF9l-Qz1LXu
Da8hOCQ2Wzef1a2WFF5pCBaZRcAK_kef65xRst6WFPjWZGCLZUqHBhFDLE0d7Ikbw7d9V8dc
4nA065NQcxfT9JDUZadS2jmQJip8GLD4P9lGS1Ry-8rHCnMN7zXDp43TfyYhSgv9uj4xKi2w
mAMMYBl0n2RNemx8nt-K_dknGgYYG0ybDkg2uAUoXdxP33KfiRjbRpYqZVAiq0S45QLAIxxG
iDJoZRnyIscdM6lryQtXj0P067vRf6ifxC3wLv97HHUKergpXcAg-4_rNj_Zx_xiHMfCAe2q
3DG1a_DcSmu5u10PkBHmzHB9Vs8HV0E2-z44sL3Exqb5L8pMYpDnZ7QW-Qb1-S-zoESUY__A
KhkRWPc7GmvmJJJHur6SRGSK0X2KyszkeYoe-8NhwplvLrYnNuV7QknBS91KH2q8C0B8FKqc
Y40S5ILkImp9iOGIXY15ZVRleoDBpH9BootWH2az5l7c_e-vfBGs7XpudoAq5wzhe_-AMBvK
PCm0BoCX5B_NGUasXvEWobqUb61mpKCuvJdzVtextk-m8Jfvmdc8ooPJEYD_oosY5_S1LuHoc
7GHLnoYdDVb2FhIPh0JCLQCef-Y3dtNThq0Eo534Zg7R72nSeSQhdQ1hcBUsc50U2oF90lOn
V9z5hsfNwIxdU09bdoXRYFmosmtpmDfGxAem0s5iPJ0EJ_8szlaX2pi6k6VP-ci-n7J8pEBw
L2R3c-ei2iqB7JdLi7Gg6iXVMpQIFtXswh0HbgGtyZXgR_-AM91XRszm_kAlqAHTAJ7B-0Z5
bJgMGEY2StBdhGzel_gNPVaxemC3DT0904GbCU2Z3avUHcedebI02_MdILDQxyXbw145Kjqc
15CqeaG--6x6WzpAuSjrFGRuz6Z5UyibW6Ay9R3P25c-gwmaRM8rPW5YkQtQdfzrtvGZ6wyh
IcBXvbpU020oChfrDF4xI2LvnaW3g6hQIUGe5lueI13ArYRAhZC0LHKPuVfv50KeMqxYRtcN
3YK6Ddc1t61rsA7MU1cAKz0GsiQ7aNyNBQH0V6z-W4-ws_DnZKYRMz0D_hwbeH00ZKhcixNg
5VDCX4hyb47LExm05N1mfihN3iHEKX_19rIgunfkSb9gd9B_AaazAttBEPPLtbsoZneQXBRl
3PWidpC_yXiLTWAd13A0BYHzBMKeJ4hp1UqsAGTaGSztbvpV92wz_YX9kMEucHMU5hoM-TJb
uWoheiiiKSFBNRK_g_rqXZo1UZjDOnHpHGjX0n1JBPP94Zvwh8sKLOpOd4qe0MLbnYKiag00
a15x_3fBxq-KI0Y310JfGdDcAKAQ0DUX71HN6XD0lvU1Iwh48iASJHdQGDmjhcS8YoeX9omw
PiYhcbGJGzEVrn3H7h24eIf_7bVRpicMhjwghB0xtqTT0eVam1l8kr1-5kem7Dr2Kyqm2HpE
wb13KPXKYDQRbHElEHazMcyR2wnjx_Bx2ai2uZa8uQyjn1zh1cjWHH0TicL2eAyc6YPKfKp
mc5QwLrgT0ddQDhvXkCkN50fOR1Sb156iFoAL8goF13QA5wBk51vsDsquEt7nLz6sGTHzknE
Nb-eEayrXnw-Q5FueFwqzoJpUrEYDXTxgOU8XVhrPv00t-B060Rfzn3_1gREChjhrc6RdF01
NNqzyVG0BdckyvwAnzUGskWdCfP62dKdx46lAIRVPd3xG4tViaQ79GAeMVnqSeCLXb0yqfn
JwhOT2fgQzLwxcj1tqGBBd3Pfx2d5-10WiL_mis0ven6golqalq1EQsveb9AJpkYgJxdBeyH
ZXxNLMh4_XAUk1ZIs9F8Cz1vFEVcAFipev-cFyRvsdcNI2-HK2nOGkypEcuVATyLtA0jKeyP
tE4TJ3_l8KXlTeZjWycQAd_8Tj9is3wisC8bfzjll8UBjFZp-rzmCr8kA4cZih9gl27TiCmh
yKhgMfDUUmuDL_Rn9DLxEAT3Eb1lSW0ToCciNtKTH9o0-wnkPd-jg1HCoolcg-K_Qk0TptJ
NZRFbXpooKqwH5Z9qsCxurZxns_MscnE0qTa4Eqr1piDnj4FBs4q9SEP1kequfYzFmjQis1i
wsReutf6pHmsvRmz9gx5vd6NMiKI05IElNDElv10GD04m1vR4ZISdmHaAgaW9_AUPGx0vP1
Rqe36cvebwUYSnzdbZ7y1s7PH7GXF5r7zNEzY9bHmXvsjb3N_u9BkenwkQfZGS6ez0AAAAA
AAAAALGSAIKzg7Qw",

```

```

"raw_to_be_signed": "65794a68624763694f694a4e54433145553045744f4463694
c434a72615751694f694a30556d3478536b354a6132644e63304643566c46436246686c5
245683451556c6a5932786f4c544a4a574442565a455246656c42304e566856496e302e5
3585469674a6c7a494745675a4746755a3256796233567a49474a3163326c755a584e7a4
c434247636d396b627977675a323970626d63676233563049486c76645849675a4739766
36934",

```

```

"raw_signature": "86632b2a452067018f415fd65285d456afd9f5639e9c365b7cc9
87a4aae2b65d1bb568b6f530bc788c90c93d4502e5b6920de1e802ecbc2ae35f9b67dd02
85419602d2c05d46dd153620e6d018f22788d67289920a06f4f9c19768b94e0c0cfe9e31
ab89d61f3b50e918cc071ec86e2aebc40afe2a9d7dd78193c4fba0bc2dae374d9ad83bc6
ebcc15c68aec8630babe4d29976af39e89a76da69ea24d4a890c1810498bcf07a3ef8a97
823e5407d99422f2a92b6b1b298b4960cbc261d9a4588f8e035f664aabe325fa17c1241e
221d1a569b03e9107ec47782e404895aa99a0f71cacf829190a72cf8fc571a86b25cf021
86b533b9237e28e4172e65e8fb58e42f27a9919af62a22b630a0bb3edff60566455d5f82
94dfca29accbc01e339b3a1cbfbd9640acc9c281f62508aac035b84e646f0ed015e0aa8c
3906abffa11233b4641932b8afa7fd424b48442daaf09308ddab21f947be3b9dd576e884
247b29facbd75a5d16485b1682f4a9806834a6e7e62c455a62000af44267da579d73d3ae
7faf9a9998e305201111562f416e6fd9ee2a4992820bd92a95b1e3c04df1de581f21b85a
5517175e1242543c3b81b6d85ac741e1c6946e102a453497f6c40ef41e9e42e55648b22e
443b6d47b91a62c6234a9973f9c2186c9ffba9c1ed1e1fe035fa5fa039de516b51fa452
2b4df390bc102f9845144d219c3de4fe17b7ffd65cf7e2e172377653e0509e0a1e27e32c
996357d23d530db4e7caf06acbad1a16762f20324df4a132a06fdcc590553bb998551154
55f3a03fd3ad1b805487583cf97655cb7f20a826c6ec1e53bd58189b4c292b32fea59e38
78733a6bae8da9ad1b490090768d5c12d5dbf69a8e303f594562a63adf233d23d75e5387
f1cba9a4c2283b5f071526c920f235ffd1a8004ea9ab29f616308e32190f5f72261a7203

```

7c5f6b921ea88f53572043c5541ac480b30e0f39d66999c52dfc369c54b4fcfaac27aba3  
56a66f1baa6fee510bb7263a9c1ca2f3ef358aa2978b1bf658edae3922a510a706cc83d2  
0213564d4dee67b0c1c02677af80b7d6935e309ef550c9156f952bdab5d51383412305ce  
8fdf96b8958d76bc83aad8436903e9b9d937d7797c572b4bed65f4fd498df7b618b811f6  
400562ff8d0ca28a8e9be8092b87afc810f9b8761f6169bbc6771889ab6c7a1d71b9ea1  
6998a62530bc310c79ca3f163b3e9cb257c1ec59f123a959405f9eacb402081b8fe8c30c  
cc64c705c20b9c00fd7be93c2369726a9bdf6f835e2b03d9c363c86949feb79cebbd2bb  
fad6d863889176b99ac1f59db3a105589dcdd8f6c24c30f3e6ba751c5e93556564ac3e51  
43a0f6b5001a059d16cff2b3bea9b3463f937bc58d83b8f4583a9dc2772c5ec833e61810  
b6e79e8535e2d18fe3e13c091deb57e05ec419c92f4dda31e615420a6cbf28f9eddb427a  
96ede6c49fbcc08d2fcb4360ed8087489de52ef38861f0076ea16f64cbf68ea6abc15267  
671d4c191d089249d7823e710eb2c5416ee0ddde06dc41ffd55afa65c1c8d34eb24fb2aa  
99a62ae37d518f154095033ea40f4be115cb23750b7a0c6ab2b3ad7183f54e7e3eb0c692  
ac5ee5c3baac1a79be0aa469e21f1fb6de710280a1bce8dff50415fc45102f62792cc482  
31231832ae783ecb8e0257d14bff019f3f43e5c7a26349414e2f580365373936b00fa0ec  
ed128d456c9d8babc82a051f4abbd6336b769800d00942f02b6935f3034b758faa9c9a1f  
96b57788d4613ef2778e26d95155bcd3e51bcf8912590159aef4f83def06cb2d034f268a  
88629f9cf6689e1ac0f1022ef90b633502b46709ae242495ebba9833433cc579f5b26919  
08bc2d8c3fd33007f67f358de6a77a2970d953d5374a2ebd6c9dc2d4924dea2743f0cabf  
b976c2ab0ba69e9daa411ceec6d0e9c0d2a4e2f3e3b2f7556a25861c56370e5106b135e3  
2d9e4fa92c92fb8f7333a8d88391cf8e7d1d7d7dc5af0e699df59f30b63db49212f89930  
e7eea4d4a3e3ec551ec69e9aa4226984984f2c6b86653c76b8fc87191856dd730a7dc6e3  
a7748365cd61ab20acb014f435c76eb35c311aedf3b1e5fd35697f1d214fca58d00675a6  
713c896a2d6e6a6c2e9d8a94aa7fd3706e564b26ce430a22d5f271d2f90336eb14095543  
47db69ffdd9ffccf5480f005fc77b8f4fa0d4f7fb3590bc7bc2299e6e01dd81a903b9e7e  
3bd5a4db25be0e51a99f832b35ecc57f84f0cafdfec517b357a74ebe76d5580e672cfbce  
d992b0ee96e3a451a462bca50bc2312d49b8a229900a8ab19f00ebb0c826dbc2804a6a6  
2f133b4005298361dfc5fdabad925a1bfff475e2aebef4581695426b179a610ed6224a5f0  
5b3317a1f50722ee43df8320791fd6a3584255ddf811935d10d51696c9351d750fe359a9  
6e8836b7183feddfdb14ac6ed08577363b3d4d3cf36863af80e2315b142b57485d66bb3b  
6acb4c5ac28adc3621d8d7cc9e2f80b0da260b2754373b8367168dc4fb021799817808bc  
5989faf626477a231d70fb096c37abf209c0ecf0978081e267d3f39a864d6682f461573f  
0515e89d49d16a241c4629b7d9df617f6ae270aec2f28cdfd28714d21687f2290cb65c27  
e854c928e1ebb9a3a99debaac419a366f4ef22d5cbbedff9e0f427121206c064646de616b0  
2964a6dda48d6511aebcd596c2c514d8a71511ecc7136ecd10e52f4f08de44954cff6b17  
deba92086c24c4e12d3e650b88750710da99f58fee2dd9cd388ed2c4e96148fb50120427  
9d9599ab6548917a06decc4d3584c8859df377d81841bbb65c9e5042756c23f6151fa447  
6e24881a03769c5e1cac1ace349ea47347d8a6bd7f42050609663ac21ebfb039117ab2f9  
af1791400d18306ccce273da6e2602c1890c17ae10f8dc1ea48d7fce5e2e4ed943591640  
0faf458e34126c8a9f02811ea9b75bbf9882a522b60cf6433e89d246193d0367d514e0b3  
31d3ef7fd8a0829230ea818375ad2f4303ffc63fdb52ddd27e5cb4a593651142ea079b85  
ee6efe2fc208d44bb2730317105870741ed1c5a19dfefeb58570fc645b470c8e0e6dc4f8de  
4edcbfd1fa9bdaf5f5be53e390234cadfd8897103104a30bd600b1b12aa116be72a0f796e  
342d3c4c17f7583cd2e30b797b991465ff07d8fc586f6b223b86b80261f32059e6fe717c  
b1e5e5ee9adf65305383ddd42d106d4851b744ee95571be6daad62b4665e370ed40c350c  
e808afc12f17c2b1a99bc9145c23a1384137ea7b9956b557fc5a2e0aa6ba1e9d6c828e3c  
c48c941d5b0e20f9a7bf6e31a37d90a9dfc460b17b56808fedbb32b2445e56c23c8df551  
2845777c5b60dcb6605e8c71765c36336cc16427edfce12a243d7ea29ed9e5a8118cb34b  
2cc6b88986c14e03ebe00eb6ba444c770d431bf3fbbf52673ece9e04ea2b17e03f9e4588  
049668f47b3f78e67ab1a7762588ef2644b316e84e0eba92ed85fc38be62b762a4c0b977  
271b162b7fb26a02431fcf9b803e2d12a8f583419abbc9cbbd06690c5c022131bd7d5c10  
e32fb859183c0346b9f9dc8105c6253da14f3578cc256247ff1c5428db13146839f89fd67  
715e2f199fab433316f1aaa8c8a70fc551a334d23276321a5b933844c7b5f9e69051e3b4  
9c460afa589a5fe192d216e57b353d562373c805afdb61e0a2ab6f5fa774a133ed5b4457  
491bf94665df7b4ee00c17f414ebe2835c1bf98bc914675357749533f98680d114553458  
0c18ce67d29281e481677003cafad693cc72c8649f6eb8174fdb2d87c706f0f184259b2d  
be313e5713901effd931baf208952ce3a5f2cdf74d761d29d7e2d67cc77696c287f713bb  
378e3cf0eea6c1b68524618a4819538a7f61299a112a7af4a55d85a90583775f66588eca

```
c0f422fd3d3beb3ddc962f028199f87b70325b8cd5c94902de28bee81f389cae59400734
7d0a4933edbdb85c65752a571ab7f3a0e2807dab188edb32595b3d860d300bd21a2c5251
cb5a7ad062fa85cf37483b31a589fc08c8682844d6f8e0844ccf3b04af1ba8aa476365ec
157383f3aee1d1955ddc58ae8ced952258bb71b4ccdab36b1f004472f01752ec848bce3e
4f111a16c985d25bef3df160f7cdee4c25ca52b0060d1263c206d77117d97e433d4bc6e0
daf213824365b379fd5ad96145e6908169945c00afe479feb9c51b2de961698d664608b6
54a870611432c439dec891bc3b77d57c75ce2700eeb93507317d3f490d465a752da39902
62a7c18b0f83fd9464b5472fbcac70a730def35c3a78dd37f26214a0bfdba3e312a2db09
8030c6019749f644d7a6c7c9edf8afdd9271a061818ec9b0e4836b805285ddc4dfd729f8
918db46962a655022ab44b8e502c0231c468832686519f222c71d33a96bc90b578f43cee
bbbd17fa89fc42df02eff7b1c750a7ab8295dc020fb8feb363fd9c7fc621cc7c201edaad
c31b56bf0dc4a6bb9bb538f9011e6cc707d56cf07574136fb3e38b25dc4c6a6f92fca4c6
290e767b416f906f5f92fb3a04494cbffc02a191158f0bb1a6be6249247babe9244648ad
17d8acacce4118a1efbc361c29bcbad89cdb9593b4249c14bdd4a1f6abc0b407c14aa9c6
38d12e482e42263fd88e1885d89796554657a80c1a47f41a28b561f66b3e65edcdefaf7
c11aced7a6e76802ae70ce17bff80301bca3c29b4068097e41fcd1946ac5ef116a1ba946
fad66a4a0ae54977356d7b193e9bc25fbc675cf28a0f244603fe8a2c639fd2d4bb87a1ce
c61cb9e861d0d56f616120f84e2422d009e7fe63776d35386a384a39df8660ed1ef69d27
92421750d6170152c739d14da817d3a53a757dcf986c7cdc08c5d50ef5b7685d16059a8b
26b699837c6c407a6d2ce623c9d0427ff2cce5697da98ba93a54ff9c8be9fb27ca440702
f647773e7a2da2a81ec974b8bb1a0ea25d5329408153c6cc21d076e01adc995e047ff803
3dd5746cce6fe4025a801d3009ec1fb46796c980c1846364ad05d846cde97f80d3d56b17
a60b70d3d3dd3819b094d99ddabd41dc79d79b234dbf31d20b750c725dcb35e392a3a82d
790aa79a1befbac7a5b3a40b928eb15046ecfa67953289b5ba032f51dcfdb973e83099a4
4cf2b3d6e58910b5075fceb6f199eb0ca121c057bdba54d363a80a17d10c5e312362ef9
da5b783a85021419ee65b9e235dc0ad84408590b42c728fb957efe4e29e32ac5846d70dd
d82ba0dd735b7ad6bb00ecc5357002b3386b2243b68dc8d0501ce57acfe5b8fb0b3f0e76
4a611333d03fe1c1b7873b464a85c8979e0e550c25f88726f8ecb13198ee4dd667e284dd
e21c4917ff5f6b220ba77e449bf6077d07f01a6b302db4110f3cbb5bb286677905c1465d
cf5a20e90bfc9788b4d601dd7700e0581f304c29e278869954aac0064da192ced6e9bd5f
76c33fd85fd90c12e70732ee61a0cf9325bb96a217a28a22921413512bf83faea5d9a355
198c33a71e91c62713a794904fa7de19bf087cb0a2cea4e778a9e38c2db9d82a26a0d346
a5e71ff77c15eaf8a234637d4e25f80374268a010d03517ef51cde970ce96f535230878f
220122477501839a385c4bc628797f689b03e262171b1891b3115ae7dc7ee1db87887ffe
db551a6270c863c20841d31b6a4d3d1e55a9b597c92bd7ee647a6ec3af62b2aa6d87a44c
1b8b728f5ca6035d045b1c494485acc098af6c278f1fc1c766a2dae65af2e4328cdd738
757235871f44e270bd9e03273a60f29f2a999ce50c0bae04f475d40386f5e40a4379d1f3
91d526e5e7a885a002fc828165dd0039c01939d6fb03b2ab84b7b9e5cfab064c7ce49c43
5bf9e11acab5e7c3e43916e785c2ace826952b1180d74f180e53c5d586b3efd0eb7e04ee
8e45fced7dfdd04447078e1adce91745d3534dab2cf2546d0175c932c2f027cd41ac9167
427cfeb674a771e3a94021154f777c46e2d562690efd18078c567a927822d76cecaa7e72
7084e4f67e04332f0c5c8f5b6a18105ddcf7f1d9de7ed745a22ff9a2b34bde9fa82896a6
8bab5110b2f79bf40269918809c5d05ec87657c4d2cc878fd702e2b5648b3d17c0b3d6f1
4455c0058a97aff9c17246fb1d70d236f872b69ce1a4ca911cb95013c8bb40d2329ec8fb
44e13277fe5f0a5e5b446635b271001dfc4e3f62b37c22b02f1b7f38e597c5018c5669f
abce60abf240387198a1f60976ed38829a1c8a86031f0d42149ae0cbfd19fd0cbc44013d
c46e5d525b44e809c88db4a4c7f683bec2790f77e8e0d470a8a0b720f8afd090e4e9b493
594456d7a68a0aab01f967daac0b1bab6719d2fccb1c9c4d2a4dae04aab9698839e3e050
6ce2af5210f94a7aab9f6331668d08acd62c2c45ebad7faa479acbd19b3f60c79bdde8d3
08908d3921e2cd0c496f94e183d389b5bd1e1921276674768081a5bdfc050f1b1d2f3f54
6a7b7e9cbde6f05184a7cdd6d9ef2d6cecf1fb197179afbccd13363d6c7997bec8dbdcdf
eef4191e9f09107d9192e9ecf40000000000000000b1920252b383b43",
"raw_public_key": "e45ffc8cc73db885dc662e62a18cd8e3803297117fa5658814a
985b5ff1db7b468cfc82bb929f1d86b77ed14f5ae16a65368772ce51912410105e045697
5ae91fdb643b512f124d5e60bd68b8c7e31fe01c7b0dc65ae470501cc565a6e1dfcfcfd1
2565433c4afedd511821e2e9610c45275e2836dee35ced69d7efa672fd1e4318bef5eb6e
897e8b451aa202ded042b2aef77a7be3f699146da229a8bdb3ffa496445967e75217bfb
c9048f9956443d8731f833eb30de10dac96fffe7cf65ea0445c3e31e8601e133be6a1007
```

64fe3196e267726441f31751fbf9a6f5880644f4e7275e57de2b0f105e4db055d50dd1c9  
c934fddf535b8de28b0c74c0449f222cd2ed0bb8fbc775ccee8c940665b40f712f4f7e00  
750e9e1e4cd9cff25d1945c3e9bca53ccd4f12eee7581856ebd68f26845956e3e7beb761  
f0fe75bdd31bf2fa018113397b387bd59d62a68b8af7fa245ab932e69f778e2ceefd213  
04fbb8099ea13d8ea57c1813197a2f75ae251075b51dad38f853669e9d5f98a365509894  
1993a1594860fba71fe530ee5c29f58f2978af688ccb75a5838a359c112e98e25a8583ac  
8dac1f861fd58e2afba5de5a52e020904f5b42bc0874e35befcf3e6119684768f36e008f  
04712177cebe627607381e56eaaee161c1729b8de51dbde474d48cc68249ea27162b8799  
3e60c84ed6cc6423cb3676d9eb50b2cab5a3a049ef131381d623fa6fbc9db1e7cc025e  
a0418b9dad2cc6ccd4e95fa2cec24feeca70318a751716b7213f63edbf65a63338357f83  
8f94ec071822c24851248885107b3d1c4e924678c7614ea1af038104619f2ae372940bec  
fa69e29cbb5ff6c3e20a47be4a4f74bac34c133c00a6a706accc6ffd3d8e4fbd69a99704  
e1283c850d8c58d1e5753cd9587b83c4c346cb9a58137213ec10834c66adfe2bb5c501a8  
ef2ecadd1b677a3df1a6deb86ebf0722c4f5030e20f9018dd5b6fc53eea24fd92b7b5b40  
25feae996d3e48fd4c650d82dbad7eaf936639698512f26253d2ef6847c8518e8565cc9a  
5495c6fff57cde7323882c54a7db470ab2daf8fffd2bf794fa7c692d9e7fbd532eccc1d78  
80e2ca0b3216128be28b4a9f1d151fac97808b0bd98b7b43a612a9ac865812bfeac6f474  
60277840b52a3b087f916ca7cedc0f768ea2bd19ea21155f84b4a04c4000ad2ae0587154  
d560bc0a477a4f9329a8984dd31eb1f2a05e3d918701d630cfca9af61ef088d2c5581acb  
463e439902e5d425719e956b8d6df7305b28e0ff27d3ad0de2085d292499b19a3390d439  
6fb3bac9a8d8cbead2a7a4290fc9ac6fca045f98a614a45a39cbe24360f84d14f8e47271  
2aceb74dbf45b53d49a0e4737e476ffc4d5b2f7cd247aa186d3b764ad9e9cfeee456a73c  
291d8de3912414ac43911c372173ad7b472af35c6853ced2fe7b5fe0a89565ab33baa6f6  
5cdd928319d7065e040e7a5e84f9aa903f7648094bad07136b16927b8ec6dbc2bef0cc28  
56de1e795923e1412c49f24deeb6c21f6c8a9765c9c7986e0da4b4c67d8e0d0c8d466824  
fb923d8573148990cd2ef133c78ceecab72ed9dd285c5a3766852d54534207ffd34027f6  
c76ede8fd1a32d72c30048bbaa797d5df6fde27d087de5721ad7b7fa3e8d3f70d6bfc3ab  
2e252335368bbfa15acb5cb37d4694e8b23cebe25de9c925a221a183b904d3f85df9929a  
919c54d6f87457373a0d6ecc1403e4cbb6e20999435e80696634cd1a8e4747e9825bfa33  
6e5bbad14f73640f1b9febe800dbaef1630c61fae635b074c564eaa9db189c9e7302873  
fc64e6d497bc5c29080987a07a21d4af210703a4fa07f2fd816f12fd1e29b4c0f44afe9b  
d4a1eaa8a7ae6f02a5b4258f52caf6127f62632a67cf4e8310be56a7c28c86b2e277600c  
3e92c8d23d42586244c571e90568df202f2f6d81f860a565f9eb91a3c78372e2a8b1be61  
c5418cf49bf2d6c8955d4a482a9919b7660b3f9a4404ffc454ea073e1e4b2689ab2cca4e  
46bd7004a6c491fa26ee7a57d60f35edb2b821e6266442c8f335d452d524c772e0353724  
c23c7dd15b7aa155e91442022140c5fcb0153147edcf3e8952f6f0399a3c88066a72756c  
9409915de63f64fa797841c57c796c6fc550ef745dfe9f179457f94755ae5a2506a764f3  
27e550be3dc14dd41f3b04b147d454938c63a8d69b2ea4c5710ec0b36e3a6c72571fa5d5  
9dde036c42033df35af056966ff0cd1204080971aa6ba9fb97b685ab9ffa2a9d1778104c  
d2c3b326de1fcbcb242e94d0311c3275b12850d3c0ceed3a2ee6d060508411d4396f5421  
d8b6d067cf7cb5e826785fbe119e05e21bd879b64f57cb0cd1972c2815f20abe7ce6ab34  
d0f471af44baad179e90644122f5f33288e689dddc5ce833e9755df1e73c65c5a201c4e  
de2ffa6b19274927719d2d38fdb7a65aa43708b7fa9a94aa7d3210253d78d3b181e1020d  
0000bd0a1dc05d447f9f58eb84c65b36c8afcb83727a1508994e826957a663b0b9b8a0  
03325ab6d6d6462ee4e106019c0dff1e10323b7bde7d82a38f85fd08786e860ba66c161b6  
4b0708c363de5c6af62d8db3c243d1e1b712cb1d59e942b9b6b4295a5a500b182cbd5fd1  
bc6ce9376d91b47a2284f1fbeb0ad1c048cc2c2fbb4afa3a9eb9697503b69fec990eba7e9  
441af9ca44cb3ac6b5ed66e591c201fe30efa8a7c471dc613d6254c263a8e132104bec47  
f1aacb3b2fcd4051b69b5e3fcb1c147a65c2f90c4b5188bafc521cab03c12a309da50b5a  
7517727ed41228ed123fe1b152f6a6319cd623bf34ad7b8e064ab993260bcdb405f5b7ff  
f9b2fa40ba5ed5630242539e5d96823e89cd818a13d16675ee3079d976f694f5acc9760a  
e789e9b3391b289e0e22a7ef17cc6a4577157b6d95c09baa4fd532e3ee0a290810ed35e5  
6bb19d9b61fb98a97c617425b06093d98a5c0ee2dd127f0eea600b9a0c67f7be761db9b7  
7e5d5bba9701da1b883e521a0cfe88451f57bd36085b67e56f061f84a2e6a152a71bce6e  
522daab6a0a33ce22e537fa9793d28b617e6c0a4176a83aa3be578afac0f2f5547c5516d  
218984755b7445c7143afa4e551fce0071bdb873b34e6b9e2b9e79ed0c69d288ed6421f2  
37e860a0c6492ebbdd2a44c2c4f368dbe99941b1e8561d859d3859f496cee3d741f25297  
3f8fcc539c409e35cc80a5ed6df23cc3a65601313f5d681fd9540c5291a9e30a72e38c96

```
413c47c61ff84fde78d011b01b4154d1b920af003f7abb1e1999dea6a766cf9fd2702b3c
e0ee57af931b62124b0861b163a3b91aa4bea28076c3432df3b29b6c4e1ba588def42007
1fc157de90eb2722ecc9ab00df3c669383a61a91bb67bd287ce349b4745ee7a479dbceef
166b9acc412eb579fcd6437307edda253d606b7be7599c38092bc52a8598480edab8b82b
1d21c565d2137ceae0b6642619b16133d91205d6355029e9cdfef9a28b373d95916b6b70
7d4c712c09cf36daf1a511b2bedb1aa70ee58d46a0666bb287784b0a3840c589a7a04d5d
6f2216be90aa4a512d5632f5c9bfe7b8b13382f999b95d367c7c46b968074ce315197a5f
f3545c7b77a804ade56a95b5c24cdece5937b5c0366d93ad03da9bc5db1b551dfb91e9b3
43d2b57b763439686d4a3"
}
```

Figure 5: *ML\_DSA\_87*

## A.2. COSE



```

2beebfc59bcd600d5309dccd72dbf0787db8ba757b537c1eafd5c0f50ea4bc9583549e28
29a42c28cac248c96d78124c47159b18aedd754aba17b19d430fb78f633ea9d26f54a9bd
50f8d8f6b73594f828976e7ea09c53bbb9f11a56c9507fb89b9a5ebc037a37267a95f85b
8d64ca97192b10a66f417b3f61fe9ca57130a48fd925eae2ab5502d571c8a51903c1d398
f4c1f76a7e11743976afdbc697f23094a3cd761ff9685de32e09fb3c28add453490300bc
7c89dc01780096071722945775f264e1b0623bcf4619c712c838761205d87691b75ef360
196cbb9e9b92a0d4c4ed62326e5024d77510b8ee2c7426cc22eae209dc9f13bde6bf08f5
e7181bd3b459450b451a51539a715c21d67dd330eb5970db00d9edbfb2822b036fa13baf
eb86d8dc78866e3f8d43e53d78cca5595a6faf886b5dc112f1cf4adcfa875800d90b4888
3af97316fe1506873fc157e570eacbfd222868d14234101966afb6bf9940829253a953ad
a89fc756b6a849f70acb9838e69faa50bba75e3e89c2adb57e86d088ab9b04a28e670709
172243ec5e0008a5ceaf3f8722f487302596ffd755ad1b82a49c34b3469515b46aa290cd
86ee38ea7a9be3f103610335b531cca333ddfef32b14510f4b07ef95fc6684e8c454a92c1
0dbb5d59c7a7c63fb305fe881967d99e669eb632840582560bb403431d40f75a49549084
82278292821f4ea91e42e78fa48caee3c836146dcfd738d117e92e9a15137d28e8e6a4b4
622650cb413504cb3a335d44beec5746c1c294b1e8cb99cb608d928f8ce3563632c521f2
3d13c61a8f61c01df8c96c7360db4f3c68aa5d2fdd342a62ff3459c116389421ab43e858
4c45882b50e6e4e96db6f0b8fde890d5dbfadcd88690b449e64240ddb2023747f308363e
301aa77757169fc6150628d5920b5aa1ab1c8cbf44cb00e025d7879d72b479e3af5311c7
85725590da9c89b9fc3b8450769554eb44d203eba2bbaef9cad2237011c2ea44eff00f29
9a48ffe28ca93ddf85f76608242ef8d6cc24610a1e2078fcac4f9385c314905ecaa82e55
3916d94d1a7c1ec652aa08897083daa2ebb1775fbc471ae27777d7904ea9f1b92bcac3d8
a3158426087b645b1108f0d65fec93789c053743ca14fd63d05e98b652df2b9c2fff9ce05
f1940703ffb273f80e0e2732eca9960d981b4cfd3b7bb8045b3c3830546b9dd8db0d', -
2: h'0000000000000000000000000000000000000000000000000000000000000000' }"
'
"sign1": "d2845827a201382f045820b8969ab4b37da9f0684e42647eb8a0be8b5b66
1ebf5d76f0583bf5b8d3a8059aa0581d68656c6c6f20706f7374207175616e74756d2073
69676e6174757265735909742657237b7520fd4cb8803f69a6e4ab613f4816420cd38e64
74e548a370c6f0a18851ce8b7bb1b43c658b795303d0f22d23aad9afc7077877ab77d7cc
92947bcf800e09626d7ceb809f74d2dc435200b272ecc92a993901087a42eaeaa6b9009d
f00f26055e6032ccca2995bf9c455e93c95adb9dda970ba07d778a9b4950169b289a86ec
272bb810f9506b960941fa4ac804de49cb80f9bd54f51adef76670c06f94bf948ad7675a
b28aa3254944753aac0cddb8594752a438552e846fb476be3e31df0c91222db5e5d70bdd
b05b624a78103654d4e9ec514f6be91cfe8fa3b8529b2659a89e70227f35d0059362ed51
c7523bf4a8ca7ceb0da6216bea77576548cd98f5ad6f87326facc8b308debce4461f1f2c
4b190bd4950eec52cb66da70c9913e8a476826a0ea05edd8f2d3ca53e485ffcebc4e7ae3
3aeeb1d8dc3ee6b8d09cea138377ceeaed4fef57d868c16311e18c64b9df501791a61420
85083850b3ad2e74901298c09b7fc4d87a660031e955b39cf9e6fbbe3cae5b36360f6b61
f904771d55d542fbc68be5468738f5b8c44eb624da535a112c0266f79b9ae7ac996feab2
c5874c65f59a72bf671b568d06e57b89f6fa168f48050f869e9fe0b95490487597e1746d
7f54ef04eca32710bd4655a2269fd9afdafa0c7630c09ad59273d5d76f6bc026b623e5fee
4fe3978efb4fdc5f905d8a346259cad9cd8ad826cdea818fcca6804bd78dddb70d46d72
3ec63980fe7bb2eb8dab84692cb6f6a560eb80381dc0d5ded38d1de896772702f99637f6
b9a9b207be86e2a401187bb250f68230f7840ecf9787bb6073e2e29f1287cd73bdf1dae8
302fcf23f942305c4c9807aba037af66f8b278003c98a30084f9ad3f2e4c4b31eb1b3f20
170c70f0310f71932a4e0065a2bd79eedc70e59f9cc261aed96fd7ebec86be2490789ad0
dffcf76f4cccc28ed675a769edf9f8d6e9fd78d59393687fb19b641626f70bbbed7c6496a3
a1393be6751f533e7af8f20f9ef32c7b58b231feb4231aa407ecf5e0be7921c449a537ab
58871b4cef2f8b1212b189ddc9e207b0ebe8135be534b30f25ce0aa33371a94971da4b6b
78bb2cb708035b539f3706348d1f6ef0e2ab9c741f1ffce5bd34c20c2ded6272c583188d
2f48404cbd10f6aa759fecb1e5b87c755573db0d86ef17fec7231179f47a19b0bcdafad
ad9a8b20dfe1d2792cc2d78d13c76722739d6c31563bc938fb07a0bc5d96d3a4e8521418
15b526ac74fa210c48ce1e2ffa3faa682191aea55a476a6cd7e0ab42902180b1444a2e08
302c17608b5831daa4c4008dbb54f0b4ce566c069ed48d4a9c5b542816f3156cde0d7323
bb071cccc98ee35672248e873b5907d02a153a57e5777c6767fd75e833df46813c2abe44
dc6492e8de4487f4fa1d1377d4ae273d28869c6630ba4865e65676d9dc9ca0998a0082e9
5c78314d543068f6fd38a27bdbc98f8b5fefa21e704e4bc8ac7ed46ea5c03eb700cf0e54

```

```
9b8a1c50b5d051bd7c2588938f7c9f5499e7b95430b1e567a2e36b4a55252829d7fb319c
7edab4e19108fa2a784c96ec1027f19f571448132b6c8c4441a7a7488ddd530b84ba022
1120c95311eab37660b1329a70365117eebbb7e0240cc5052ec723e0121c2a175053c762
b88943ac7b965d10239c4b8f8d39a1a57ace097a1631c7e93c36abc8a085a21a18a14b62
1cff49369707891e06e508e41970b26490c8f5c038bcb2e62a72d24591f563c42fed3dfa
3539f75dacbc7918919642220a01da483a2c0413360e424c6cc30dfc502858a57ffdc20d
30bb57c1659a7d4beb6794c4675524e813a27e3807547d0bc16e91242d7925b01f0a8cf0
3f5c6e867710373ad02e53816f82a21b2c9f359e7d586ec0590c0a1780a6755e1723981e
bd866d251e20a0a5b2dc08e05beb325797aa7c2746596c534964cc751ff341d49e39c8b6
f8a903549779189c5732b841abde352eddf9fffb67f20b9c27d30078994ac96c8250b342
8c65a714c05c91c897a18ee58f908557062bd733444a9d73ed89a637c62143e46e1cb372
3c6a8fd2df0d90d03b6cdfb4e6c033f67c51a803b6eaea79e0ecfe4a3b22c5dc951d5168
3ea716149958c59ab43f1085d8e5896aa3c8d972d54998d3de2b27c2d67e0059b78dff6f
804cd491dfae0308b4c8983ea1c574b4414df8ca772fbb60dc49249f8dbab9c433570168
93f7a4b2eb28c0a8de635157b717e20ad60d5a52d37e2ebf5b87dcccdd1f40825d56b
948e60015118e8988f6000dd157ce92a0f0ec1d5459890317ee861a0d29f730533104788
6e1918b8438d1df534e685c93f2f11317b000b0bd7da766e5f1d4a0816a7af878be4c8dc
8fdd208abd5c7f98aa0e882772387ef5032f60e71a7c1c630a8eacdde2a7c5e86277b20e
1317cd8b9892e8509647d55143dcca07ffdd678d5856eaab93f55df72ff4c909146de54
393aed095cbd9fc1a24b7f7950cb80eb423ed114cdc21e59593b2a5fcbdbdf1613810fd6
3c8dd45e39bc5bd02d71328cfea87d2deadda75089ca7d4529e0b5b64fb887fc38cb9531
033386255c6a155af95447b2154354e6d163b752bef91f248b5068f3e620365c8c497cfc
bc6f1930d0cf08387308310f485bfa23c31bf2d01900e801352a388c97212ef58b6a81f50
82f08831433a7ca8c0df910cc462b36d61f532325eeee540547b6c07c738b010daf7384f
8cf01975761101e556e8639848dfd049ee5360bb9b62bb38aef0fc84970dad3e78c0f341
3573042abe52805b5aec545bcb43142f5d44a9c1d2b6cdf3ded20907f02ebc78e78f598b
eadd0fc1faa676560edfbbd7a83b61795bc29b6fbc4c7c6e9097139dbb85b54a8b446a37
f2fd6a7db528f1c5da5fe367823f8fa39adae0bd23196f689059e2de3cfcbaad6bec7104
64156cd72be70d5950075953286feb605f6898746586750e3aef767b0e80136453c1ab38
8ff5462bfc0316ed78937ea235dd883e9fedbd66f9060b542272ac9747fe3109a27a8940
3fc1c2380ccb1e3f199077582aa565fba4621092c5665f2f7803f5ecfdaf86878ec045a7
80ea3751bd3233cd02fef8b4eb9386f51fa7a5f3bb81c55fb0de38c905ba4002dadfcc5
123bf561bef2d32c40577dc487736162c69444279d917abd0d2320fb715299c1043defb5
82a20fec3190a6c0e484360910388889c122c4a13adc73031a0969e3c1a9008d8467c4c4
d59c848d9ca2441ec57b02034fd5872b4cf75185d5fb14e6af1ead0e1727db42db39877
f01d674558f7b59b0e0f10363e3f505d82a7c0c7cadd1618233541424f57596476777d80
a6b8dfe6eefcfd0515196c8e99c3cfd2ebf2020b0c16202b3337484e525657a4b5bec3ca
d2d4d5d6dd0000000000000000000000e232e45",
"sign1_diag": "18([h'a201382f045820b8969ab4b37da9f0684e42647eb8a0be8b5
b661ebf5d76f0583bf5b8d3a8059a', {}, h'68656c6c6f20706f7374207175616e7475
6d207369676e617475726573', h'2657237b7520fd4cb8803f69a6e4ab613f4816420cd
38e6474e548a370c6f0a18851ce8b7bb1b43c658b795303d0f22d23aad9afc7077877ab7
7d7cc92947bcf800e09626d7ceb809f74d2dc435200b272ecc92a993901087a42eaeaa6b
9009df00f26055e6032ccca2995bf9c455e93c95adb9dda970ba07d778a9b4950169b289
a86ec272bb810f9506b960941fa4ac804de49cb80f9bd54f51adef76670c06f94bf948ad
7675ab28aa3254944753aac0cbd8594752a438552e846fb476be3e31df0c91222db5e5d
70bddb05b624a78103654d4e9ec514f6be91cfe8fa3b8529b2659a89e70227f35d005936
2ed51c7523bf4a8ca7ceb0da6216bea77576548cd98f5ad6f87326facc8b308debce4461
f1f2c4b190bd4950eec52cb66da70c9913e8a476826a0ea05edd8f2d3ca53e485ffcebc4
e7ae33aeeb1d8dc3ee6b8d09cea138377ceeaed4fef57d868c16311e18c64b9df501791a
6142085083850b3ad2e74901298c09b7fc4d87a660031e955b39cf9e6fbb3cae5b36360
f6b61f904771d55d542fbc68be5468738f5b8c44eb624da535a112c0266f79b9ae7ac996
feab2c5874c65f59a72bf671b568d06e57b89f6fa168f48050f869e9fe0b95490487597e
1746d7f54ef04eca32710bd4655a2269fd9afdafa0c7630c09ad59273d5d76f6bc026b623
e5fee4fe3978efb4fdc5f905d8a346259cad9cd8ad826cdea818fcca6804bd78dddb70d
46d723ec63980fe7bb2eb8dab84692cb6f6a560eb80381dc0d5ded38d1de896772702f99
637f6b9a9b207be86e2a401187bb250f68230f7840ecf9787bb6073e2e29f1287cd73bdf
1dae8302fcf23f942305c4c9807aba037af66f8b278003c98a30084f9ad3f2e4c4b31eb1
```



a3254944753aac0cdbd8594752a438552e846fb476be3e31df0c91222db5e5d70bddb05b  
624a78103654d4e9ec514f6be91cfe8fa3b8529b2659a89e70227f35d0059362ed51c752  
3bf4a8ca7ceb0da6216bea77576548cd98f5ad6f87326facc8b308debce4461f1f2c4b19  
0bd4950eec52cb66da70c9913e8a476826a0ea05edd8f2d3ca53e485ffcebc4e7ae33aee  
b1d8dc3ee6b8d09cea138377ceeaed4fef57d868c16311e18c64b9df501791a614208508  
3850b3ad2e74901298c09b7fc4d87a660031e955b39cf9e6fbbe3cae5b36360f6b61f904  
771d55d542fbc68be5468738f5b8c44eb624da535a112c0266f79b9ae7ac996feab2c587  
4c65f59a72bf671b568d06e57b89f6fa168f48050f869e9fe0b95490487597e1746d7f54  
ef04eca32710bd4655a2269fd9afdfa0c7630c09ad59273d5d76f6bc026b623e5fee4fe3  
978efb4fdc5f905d8a346259cad9cd8ad826cdea818fcca6804bd78dddb70d46d723ec6  
3980fe7bb2eb8dab84692cb6f6a560eb80381dc0d5ded38d1de896772702f99637f6b9a9  
b207be86e2a401187bb250f68230f7840ecf9787bb6073e2e29f1287cd73bdf1dae8302f  
cf23f942305c4c9807aba037af66f8b278003c98a30084f9ad3f2e4c4b31eb1b3f20170c  
70f0310f71932a4e0065a2bd79eedc70e59f9cc261aed96fd7ebec86be2490789ad0dfc  
76f4cccc28ed675a769edf9f8d6e9fd78d59393687fb19b641626f70bbbed7c6496a3a139  
3be6751f533e7af8f20f9ef32c7b58b231feb4231aa407ecf5e0be7921c449a537ab5887  
1b4cef2f8b1212b189ddc9e207b0ebe8135be534b30f25ce0aa33371a94971da4b6b78bb  
2cb708035b539f3706348d1f6ef0e2ab9c741f1ffce5bd34c20c2ded6272c583188d2f48  
404cbd10f6aa759fecb1e5b87c755573db0d86ef17fec7231179f47a19b0bcadafadad9a  
8b20dfe1d2792cc2d78d13c76722739d6c31563bc938fb07a0bc5d96d3a4e852141815b5  
26ac74fa210c48ce1e2ffa3faa682191aea55a476a6cd7e0ab42902180b1444a2e08302c  
17608b5831daa4c4008dbb54f0b4ce566c069ed48d4a9c5b542816f3156cde0d7323bb07  
1cccc98ee35672248e873b5907d02a153a57e5777c6767fd75e833df46813c2abe44dc64  
92e8de4487f4fa1d1377d4ae273d28869c6630ba4865e65676d9dc9ca0998a0082e95c78  
314d543068f6fd38a27bdbcb98f8b5fefaa21e704e4bc8ac7ed46ea5c03eb700cf0e549b8a  
1c50b5d051bd7c2588938f7c9f5499e7b95430b1e567a2e36b4a55252829d7fb319c7eda  
b4e19108fa2a784c96ec1027f19f571448132b6c8c4441a7a7488dda530b84ba0221120  
c95311eab37660b1329a70365117eebbb7e0240cc5052ec723e0121c2a175053c762b889  
43ac7b965d10239c4b8f8d39a1a57ace097a1631c7e93c36abc8a085a21a18a14b621cff  
49369707891e06e508e41970b26490c8f5c038bcb2e62a72d24591f563c42fed3dfa3539  
f75dacbc7918919642220a01da483a2c0413360e424c6cc30dfc502858a57ffdc20d30bb  
57c1659a7d4beb6794c4675524e813a27e3807547d0bc16e91242d7925b01f0a8cf03f5c  
6e867710373ad02e53816f82a21b2c9f359e7d586ec0590c0a1780a6755e1723981ebd86  
6d251e20a0a5b2dc08e05beb325797aa7c2746596c534964cc751ff341d49e39c8b6f8a9  
03549779189c5732b841abde352eddf9ffbf67f20b9c27d30078994ac96c8250b3428c65  
a714c05c91c897a18ee58f908557062bd733444a9d73ed89a637c62143e46e1cb3723c6a  
8fd2df0d90d03b6cdfb4e6c033f67c51a803b6eaea79e0ecfe4a3b22c5dc951d51683ea7  
16149958c59ab43f1085d8e5896aa3c8d972d54998d3de2b27c2d67e0059b78dff6f804c  
d491fae0308b4c8983ea1c574b4414df8ca772fbb60dc49249f8dbab9c43357016893f7  
4ab2eb28c0a8de635157b717e20ad60d5a52d37e2ebf5b87dcdccdd1f40825d56b948e  
60015118e8988f6000dd157ce92a0f0ec1d5459890317ee861a0d29f7305331047886e19  
18b8438d1df534e685c93f2f11317b00b0bd7da766e5f1d4a0816a7af878be4c8dc8fdd  
208abd5c7f98aa0e882772387ef5032f60e71a7c1c630a8eacdde2a7c5e86277b20e1317  
cd8b9892e8509647d55143dcca07ffdd678d5856eaab93f55df72ff4c909146de54393a  
eed095cbd9fc1a24b7f7950cb80eb423ed114cdc21e59593b2a5fcbddf1613810fd63c8d  
d45e39bc5bd02d71328cfea87d2deadda75089ca7d4529e0b5b64fb887fc38cb95310333  
86255c6a155af95447b2154354e6d163b752bef91f248b5068f3e620365c8c497cfcbe61  
930d0cf08387308310f485bfa23c31bf2d01900e801352a388c97212ef58b6a81f5082f0  
8831433a7ca8c0df910cc462b36d61f532325eee540547b6c07c738b010daf7384f8cf0  
1975761101e556e8639848dfd049ee5360bb9b62bb38aef0fc84970dad3e78c0f3413573  
042abe52805b5aec545bcb43142f5d44a9c1d2b6cdf3ded20907f02ebc78e78f598beadd  
0fc1faa676560edffbd7a83b61795bc29b6fbc4c7c6e9097139dbb85b54a8b446a37f2fd  
6a7db528f1c5da5fe367823f8fa39adae0bd23196f689059e2de3cfbaad6bec71046415  
6cd72be70d5950075953286feb605f6898746586750e3aef767b0e80136453c1ab388ff5  
462bfc0316ed78937ea235dd883e9fedbd66f9060b542272ac9747fe3109a27a89403fc1  
c2380ccb1e3f199077582aa565fba4621092c5665f2f7803f5ecfdafe86878ec045a780ea  
3751bd3233cd02fef8b4eb9386f51fa7a5f3bb81c55fb0de38c905ba4002dadfcc5123b  
f561bef2d32c40577dc487736162c69444279d917abd0d2320fb715299c1043defb582a2

```
0fec3190a6c0e484360910388889c122c4a13adc73031a0969e3c1a9008d8467c4c4d59c
848d9ca2441ec57b02034fd5872b4cf75185d5fb14e6af1ead0e1727db42db39877f01d
674558f7b59b0e0f10363e3f505d82a7c0c7cadd1618233541424f57596476777d80a6b8
dfe6eefcfd0515196c8e99c3cfd2ebf2020b0c16202b3337484e525657a4b5bec3cad2d4
d5d6dd0000000000000000000000e232e45",
  "raw_public_key": "ba71f9f64e11baeb58fa9c6fbb6e14e61f18643dab495b47539
a9166ca0198131c44f826bbd56e34e55db5e5e2d733485e39ea260fc6000c5ea4ba80d34
55cde53b46f34482aedfd5450fc2e1ba4f25d15f9c144242fb39bb52287189030c50498e
1717b7c758b190a6748ea9aa3f7acaaf2c7cb526ed717c9f79aeb84214fa5cd8ded92a0c
3fa1558810f12c7050a367708d196cd24e5af974904aed8e4ce8872e8696b0b7bca50e45
2cd7d30ea9a4adac0311d672c6bde8496240b07431463708895cd9bafc31632d73976493
88fdafcbf7d305a3de9a495eca7433a8f83ba0f0b25c413c6e39c96eb7d691b34d37ce37
f1ead1cf217e25ef34eef3f7c60f84b8edfdde8405d4f832576c61ef98e0a2f28da187
700953924f686b94614705bcf53d33fedd4348edddbdf28b5065e1f20775043e85cf931f
829179363a1a7e7404a838ec00086b0976386fe637c98244757e3f769ddd4467471bfad6
70f9a05f8246ee50a7b1eaf87fc4069c3ae2aa2033258117792f0bcd49e083fd1bc7496a
bff29cc94e4868b21214ed316525399a610fbdd4a80e7c80715f29578e2a84bb40bddd4bd
9f47a11b6e7da118a1b658d359e8aef55eb46b5376b5b655979984a922beebfc59bcd600
d5309dccc72dbf0787db8ba757b537c1eafd5c0f50ea4bc9583549e2829a42c28cac248c
96d78124c47159b18aedd754aba17b19d430fb78f633ea9d26f54a9bd50f8d8f6b73594f
828976e7ea09c53bbb9f11a56c9507fb89b9a5ebc037a37267a95f85b8d64ca97192b10a
66f417b3f61fe9ca57130a48fd925eae2ab5502d571c8a51903c1d398f4c1f76a7e11743
976afdbc697f23094a3cd761ff9685de32e09fb3c28add453490300bc7c89dc017800960
71722945775f264e1b0623bcf4619c712c838761205d87691b75ef360196cbb9e9b92a0d
4c4ed62326e5024d77510b8ee2c7426cc22eae209dc9f13bde6bf08f5e7181bd3b459450
b451a51539a715c21d67dd330eb5970db00d9edbf2822b036fa13bafeb86d8dc78866e3
f8d43e53d78cca5595a6faf886b5dc112f1cf4adcfa875800d90b48883af97316fe15068
73fc157e570eachfd222868d14234101966afb6bf9940829253a953ada89fc756b6a849f
70acb9838e69faa50bba75e3e89c2adb57e86d088ab9b04a28e670709172243ec5e0008a
5ceaf3f8722f487302596ffd755ad1b82a49c34b3469515b46aa290cd86ee38ea7a9be3f
103610335b531cca333ddfe32b14510f4b07ef95fc6684e8c454a92c10dbb5d59c7a7c63
fb305fe881967d99e669eb632840582560bb403431d40f75a4954908482278292821f4ea
91e42e78fa48caee3c836146dcfd738d117e92e9a15137d28e8e6a4b4622650cb413504c
b3a335d44beec5746c1c294b1e8cb99cb608d928f8ce3563632c521f23d13c61a8f61c01
df8c96c7360db4f3c68aa5d2fdd342a62ff3459c116389421ab43e8584c45882b50e6e4e
96db6f0b8fde890d5dbfadcd88690b449e64240ddb2023747f308363e301aa77757169fc
6150628d5920b5aa1ab1c8cbf44cb00e025d7879d72b479e3af5311c785725590da9c89b
9fc3b8450769554eb44d203eba2bbaef9cad2237011c2ea44ef00f299a48ffe28ca93dd
f85f76608242ef8d6cc24610a1e2078fcac4f9385c314905ecaa82e553916d94d1a7c1ec
652aa08897083daa2ebb1775fbc471ae27777d7904ea9f1b92bcac3d8a3158426087b645
b1108f0d65fec93789c053743ca14fd63d05e98b652df2b9c2ff9ce05f1940703ffb273f
80e0e2732eca9960d981b4cfd3b7bb8045b3c3830546b9dd8db0d"
}
```

Figure 6: ML\_DSA\_44







```

d877ac6396d88a2df32c74eff79b9dbf1504b3cd55bcbbfa8ab2a16979dfa53631a5d7d9
48bdc26c37eed9d2e2855338d029365b63b6b22abc211ed2ac1d3974550d2d783be4c8b2
86fd8868a7c221ba15a527b1ccd14c50fc85907016930691f44f593a9c4ed3a1cec24f02
6735b719275fe27af036d234baeb812c5d60babae2f2b7032f0ad34a09cf98537a8b623f
266eee28151acaa735af300ad6ce3e33c982b46db37479d5e3ad808b22b1453451dee5db
ac26a03ae64990917b7060ee48281e1b8c486218a8c20d371f621fdd4466254c5d3cab08
fc07dc96b41c83d755377fe0363d11969802431cd4f2ff5cb92eb362591f12cf6f69fcd2
5727309235aa75acdd915c5a09403194a27b2f3b11cf51240ffeb0a457d383dd49503d30
21ee19e83ef1b5d7f0aa243c7a4b69978e1ef33911ecc320351a1e459ee1f672be88db2f
0f5755758468a4509d067f5edafb45334179d1317a4130e45320019cdc3113222c7933f0
d12f3a71b23461cb9ebf072c3f7001797c9124bb7f39778c7b393eeadeee2f6fd9ed76f3
9d16291722bf9bf68761e307438649ee7e0042e7801e8c46d741fb216b13ab8d243c608d
7d5cc6cc758d429c90b9ac1dc1275314bd506fbd4e41767c8e8ec02282375b4f9e2d77b7
8c1c00dfd527c07506d0803dd2b9963535281cb9473f03c37fc34b22aca3fea6630dc1f5
3e7ce938c9dbe3550076fd724675107f2cbdf186389f189492f6388da43baf6f9ea72982
f665dcb1ec9f861021ee974abb8d0e36da8187dbb5dbe0c7100f0c07fb6c0702e84e9591
ee3c6cd9ca2482079556559ed691dbd97dc0bb1f052d64a938e260795192a876f97bf340
97eb4380cb16e7415f58021fdf7dec9df8e521575b62d618bfc331b7efc3ea92394f73a0
808df15e8794818649d9675edf3daaed3c5170a843d448bd1ec5d2e8e5dfd4254e334f4a
d27d73b614fe0f8542a0a644f6f824422e8e1e10cd125b9363da6f015354baa244921f89
60ebc44f97ad1a29330ac6adbce3269922e9a1990feb9e4c89a7e34368a04b79f5db62cd
a84af2ba028594de966674fa11ed21634922f8e5b4dbc0b9c9c899881dcaba8d6724d114
b231b1dc3088337a45070f5846c742f6184b0f0a1e55fe87bf37822cfc3ddb356c397ef8
5d9c1c0c65db191a9d03469096c2ce42b919145708e3ee8b35e8d72db1c738d3a4389ae9
96f9604ea6903e61ac0bbe56c8ba108cda00d1bdcc6904644705c9a858adc8cdc08f4449
ef11f4d0e28550586478ac6c8a8c8aed3927ca90e3b31fc8f5722aa68ad028642c14706b
8ab0e413201305f9f1a899f2ddd5fb6eff9985d0e57009956bc24f1d2c7b420eb3716a28
4df6408e38cedc4c7ec1c11c205c8567cda8b12d4d8d97691015be532160a5a1731d8af5
bd17a35f0d958ca423abfd1c6346f9472ba7d7aa70b845ff343acd9f153aa939bcd101f0
578fafa84d4cc77c5b67eff3bdbc5bea27b703d4ca3cb5c4f4943855ff512517b2f2c57535
bcc47726e7c2cc739dc65cf805b018167ce1324ea5578f9af0378eb281c2a3b28fdab577
5a4249bbe587c06077eb20c1ddab672d4206cbcb0d48b461b92bdee4249408f132e3a36e
63e8ebd8dced63ef150da21c8264bdc65379a39f0331895e6d589444d9dbd56f7626252d
7145905dab7ed44ab0d14707fb1c19198196da8fc7388056a7a59fb0e19cc05d88ce6a60
802c73f9d785b48992318ae993397044f43c38709c319ef5a8e68a452bc5b79bd86ae509
81e58f7cbc58c7e17946804ab019c18a570c499e8b425a600201ef63a40f7d918b60ec9e
eba668201cdab4624c35fcd014cdfaf2e7749e056f195f1eefc1949420e5569c461bc26f
888b1aca0418552ad2dc1c5b62e6c972b60ba643344d52cbdade3286497595a5adc1c40d
0f10366cc9dbf9fb0e22445d5e7ba14c759fbfd1d4000000000000000000000000000000
0000006080f181f25",
"sign1_diag": "18([h'a2013830045820b788acf242f1f1d6532926d816e76e16368
74267f2a48c84c4e65789ab80cc02', {}, h'68656c6c6f20706f7374207175616e7475
6d207369676e617475726573', h'd5bd2448903e4f81fb949158eefdeb93e2f40e58d3f
fe5703d23954aeb547b2f490226b7e4bc617a90156acd6afa662c0a5fe83be1f9e2d4584
36f9b9119c853c71fa7c7591b6471d9d68366d5bf12833c182ac927f7f0edd816e52ecea
715c66e71e35029083fd26d0f16040e1da74b378950429fae8229af0495104549e2de909
d6f8be09fcfc982e08425da663c181e862510b647f2f679ec16b7226fae6a9b90d8131c7
80a984b231c45811156470c143a5a9a611248532b574d40c0ef9728264892ad97d523ca9
146a8f965996dda13bc7eacde9040a7745a92790c2ec6672d8a665761495c873ddd4b9dc
347db786ccfeabfb4f584bae9086f43639ade01f6c81a8f15d3c01ec9aaf0b04699c3816
3de65967cc921acc66935cbea43f393d9f65303a4640c081a6073f762fd78c532911ecc
60400688e329d7bca72d24fec7c8cd307130f0dfb37ce333470501d9e2ff16810ede1fc8
11873fe8b38cf1c656d1927c190d240c0020514b9e71f6ad14fee3baac3444111c6a1a16
76dc92036e481c35b9db29a6282fa619a8b0110265b870f57c9b42d48b223c348b0621f5
5654fed735bae9344bae117deb583ab54e66a26f360468c47e3e40f553127164bb3eb803
d17cb76d18d576d942db7c18b5870fb26699b13e91f15c75b35d55eb2b10f6ffad617ee2
c77b6bfa2fc1b2a4cb2703a528959f80d02e9325c88aff95cd51351cb6992e4e04ff124
968d790056eef96664ed015c4563ec71807022f6b92d8542a0feda0b8190ac2db5ea9c96

```

7836cda38839ce3bd5f46369bdb752fec8b047f4fb4608d6b21afc294564ac9d94356623  
7f7a6dccebc1805cef60303f6058d43b7b612cce12232e5a895f9e5237da5461b8ee1790  
7b7cae08d25488f80c786c849103d4c44c2c6bca1b57e9a3b55f307c9c299e322a9ec81  
abfcc5f38fe036fb17fa343748ef746f0e31350d05a47d0f37002b55624df95831c72ddc  
e2dfd91382879b1673f5fcb1600c65d560034ee163eeb5c11164ef88efed87f4e364fcd6  
e9d6cea384a62afbba34a6b4bdbd1b270a733a804d2f58703cc99a91e8ce88d992f685b  
08d7ede6d36fc821e5094cc69085896f60b2a9d9cacb0c4d77bd44eab94f11638b4798c3  
e462b8e020e4f22f0e14782051f16f2d7cb314dc24d4820549ff27ad458408d1a663f5f5  
fc22a4e921ff26c97fa84c5f12d35ad9c89310d0c9c075ba373024a1dc208f5f17c592b5  
b5c3bdf4129bf304b2b731d383b844ffc48a234c0d07ff8ff550619f6b6eff3cad399c1a  
2b61bd4aa68a7fd86cf661f73a309c3baf512b6fc81f7702857d350744958be7050aac6  
d1f040bfd866df38727df3bfd1ff3896f68550dfcb520c308fea4d1716790b1b6d51ef9c  
815e05d537c64460893beb9d82c350393ad15992e1c1ba16ff59a87c5d6fa19b4e88e2c4  
33e0e96ffc6a8a7d49f84769ff9057bef8daf353e8516a852247e2f17ff13c81be266fff  
7c916c9b726a83058c66ac0366335ee6e7b079095cf367bf79a3cc38da62d53e84a3b1a4  
ca97f40dd147e0d6c90dec5aa93c178096884fc7718a675eee7900e4cb3ccc3601a08bf0  
003c3a029ca62a1924cc5bb83b29817f892c5a5e7253abeb536d58d885008914a94bb274  
7f8a22478f35490d6f9693d0ff50073289adda762b62823a9e4b134478642d9f1c44e205  
59bc5506df6baf76056c9cfbf15bb7134cd95f29527f006a0a49ebc4bb8e8ccfe3757a1f  
61c83a25ef44d2856f15d13272de73bfe726df6a775b18157c85d419d20a7614dc18eb74  
dfb26af89fb2996ebcfef37dbdf37d3d2408411f9aad75f6d2cae122bf90e51ad6c4f6b  
bf85c50a50e78afaf86fa5e367d00c4fdade27148949fb8db485eb7950d63c90013313db  
410ecf9b314a94c102dc8bf7e9e27ffdbedd64b9441bc687a534874739c527590d1af213b  
f8ebd916e456561973f822e26aae6827b06ec4fcd45c146ac5c6637168e024c188f93315  
dd57e7fb8a12879d1a83fbd2421368a1dbf54898b487951c24ad2535a0344d7f7380808d  
44b207ac16b490c51155d275da3b863f775a13c8483f05c76aa6b64e8faf96fb2ff78672  
361d139183abe3957c6f431b342779e2fa96b07de7a530469d7096c01567c0c1ec7d3556  
d0ac636a9482a84aef2087ad2c2bbb5fc49739c16d771203529b1134da0d0373a4e23057  
41711a21016a132cd213fe2867b37465a103b68e16ce6ada0cbe1da2a0590f2a6d1afa8e  
06e29b4dc3c9ae21ef6ca67e3c34a0e8f43dfaa0882d24e7fcc770ff28450efa19b88de8  
3e8327e499b15529745473ce9e1da81e9ce0fa1a816100c8d08741bfc8260fb0a6624c3  
73b5823b587b34d16d1bddb6a03501f6e8ccac59b877ee751cc841f2290eb8c37fbf119b  
93dbe6b0a700e3ee8e7a697b80d1a304a71e3c1ebe734a412a8403c80d9ca3096c3a764b  
f8f6524427efd2648210a387fdcfd05e4bbb6c353437750324b320458aaff555fe41765  
bb827c3c43d80bee1ef45dd3993d06ab1245e9c95aa7976f54ba17aa031c8694e9b167a9  
86cc289e534f1359f14ae335f7c41683dc85ccaf4ee2b4c1cdd2116552f396ac8d6567e0  
f458c8cc0342086c31c0f8bffa3ac0d31677b10494c45e68e66432b3f270a25cd389c126  
943b1d877ac6396d88a2df32c74eff79b9dbf1504b3cd55bcbbfa8ab2a16979dfa53631a  
5d7d948bdc26c37eed9d2e2855338d029365b63b6b22abc211ed2ac1d3974550d2d783be  
4c8b286fd8868a7c221ba15a527b1ccd14c50fc85907016930691f44f593a9c4ed3a1cec  
24f026735b719275fe27af036d234baeb812c5d60babae2f2b7032f0ad34a09cf98537a8  
b623f266eee28151acaa735af300ad6ce3e33c982b46db37479d5e3ad808b22b1453451d  
ee5dbac26a03ae64990917b7060ee48281e1b8c486218a8c20d371f621fdd4466254c5d3  
cab08fc07dc96b41c83d755377fe0363d11969802431cd4f2ff5cb92eb362591f12cf6f6  
9fcd25727309235aa75acdd915c5a09403194a27b2f3b11cf51240ffeb0a457d383dd495  
03d3021ee19e83ef1b5d7f0aa243c7a4b69978e1ef33911ecc320351a1e459ee1f672be8  
8db2f0f5755758468a4509d067f5edafb45334179d1317a4130e45320019cdc3113222c7  
933f0d12f3a71b23461cb9ebf072c3f7001797c9124bb7f39778c7b393eeadeee2f6fd9e  
d76f39d16291722bf9bf68761e307438649ee7e0042e7801e8c46d741fb216b13ab8d243  
c608d7d5cc6cc758d429c90b9ac1dc1275314bd506fbd4e41767c8e8ec02282375b4f9e2  
d77b78c1c00dfd527c07506d0803dd2b9963535281cb9473f03c37fc34b22aca3fea6630  
dc1f53e7ce938c9dbe3550076fd724675107f2cbdf186389f189492f6388da43baf6f9ea  
72982f665dcb1ec9f861021ee974abb8d0e36da8187dbb5dbe0c7100f0c07fb6c0702e84  
e9591ee3c6cd9ca2482079556559ed691dbd97dc0bb1f052d64a938e260795192a876f97  
bf34097eb4380cb16e7415f58021fdf7dec9df8e521575b62d618bfc331b7efc3ea92394  
f73a0808df15e8794818649d9675edf3daaed3c5170a843d448bd1ec5d2e8e5dfd4254e3  
34f4ad27d73b614fe0f8542a0a644f6f824422e8e1e10cd125b9363da6f015354baa2449  
21f8960ebc44f97ad1a29330ac6adbce3269922e9a1990feb9e4c89a7e34368a04b79f5d



```
fb2996ebcefe37dbdff37d3d2408411f9aad75f6d2cae122bf90e51ad6c4f6bbf85c50a5
0e78afaf86fa5e367d00c4fdade27148949fb8db485eb7950d63c90013313db410ecf9b3
14a94c102dc8bf7e9e27ffdbedd64b9441bc687a534874739c52759d1af213bf8ebd916e
456561973f822e26aae6827b06ec4fcd45c146ac5c6637168e024c188f93315dd57e7fb8
a12879d1a83fbd2421368a1dbf54898b487951c24ad2535a0344d7f7380808d44b207ac1
6b490c51155d275da3b863f775a13c8483f05c76aa6b64e8faf96fb2ff78672361d13918
3abe3957c6f431b342779e2fa96b07de7a530469d7096c01567c0c1ec7d3556d0ac636a9
482a84aef2087ad2c2bbb5fc49739c16d771203529b1134da0d0373a4e2305741711a210
16a132cd213fe2867b37465a103b68e16ce6ada0cbe1da2a0590f2a6d1afa8e06e29b4dc
3c9ae21ef6ca67e3c34a0e8f43dffa0882d24e7fcc770ff28450efa19b88de83e8327e49
9b155529745473ce9e1da81e9ce0fa1a816100c8d08741bfc8260fb0a6624c373b5823b5
87b34d16d1bddb6a03501f6e8ccac59b877ee751cc841f2290eb8c37fbf119b93dbe6b0a
700e3ee8e7a697b80d1a304a71e3c1ebe734a412a8403c80d9ca3096c3a764bf8f652442
7efd2648210a387fdcfd05e4bbb6c353437750324b320458aaff555fe41765bb827c3c4
3d80bee1ef45dd3993d06ab1245e9c95aa7976f54ba17aa031c8694e9b167a986cc289e5
34f1359f14ae335f7c41683dc85ccaf4ee2b4c1cdd2116552f396ac8d6567e0f458c8cc0
342086c31c0f8bffa3ac0d31677b10494c45e68e66432b3f270a25cd389c126943b1d877
ac6396d88a2df32c74eff79b9dbf1504b3cd55bcbbfa8ab2a16979dfa53631a5d7d948bd
c26c37eed9d2e2855338d029365b63b6b22abc211ed2ac1d3974550d2d783be4c8b286fd
8868a7c221ba15a527b1ccd14c50fc85907016930691f44f593a9c4ed3a1cec24f026735
b719275fe27af036d234baeb812c5d60babae2f2b7032f0ad34a09cf98537a8b623f266e
ee28151acaa735af300ad6ce3e33c982b46db37479d5e3ad808b22b1453451dee5dbac26
a03ae64990917b7060ee48281e1b8c486218a8c20d371f621fdd4466254c5d3cab08fc07
dc96b41c83d755377fe0363d11969802431cd4f2ff5cb92eb362591f12cf6f69fcd25727
309235aa75acdd915c5a09403194a27b2f3b11cf51240ffeb0a457d383dd49503d3021ee
19e83ef1b5d7f0aa243c7a4b69978e1ef33911ecc320351a1e459ee1f672be88db2f0f57
55758468a4509d067f5edafb45334179d1317a4130e45320019cdc3113222c7933f0d12f
3a71b23461cb9ebf072c3f7001797c9124bb7f39778c7b393eeadeee2f6fd9ed76f39d16
291722bf9bf68761e307438649ee7e0042e7801e8c46d741fb216b13ab8d243c608d7d5c
c6cc758d429c90b9ac1dc1275314bd506fbd4e41767c8e8ec02282375b4f9e2d77b78c1c
00dfd527c07506d0803dd2b9963535281cb9473f03c37fc34b22aca3fea6630dc1f53e7c
e938c9dbe3550076fd724675107f2cbdf186389f189492f6388da43baf6f9ea72982f665
dcb1ec9f861021ee974abb8d0e36da8187dbb5dbe0c7100f0c07fb6c0702e84e9591ee3c
6cd9ca2482079556559ed691dbd97dc0bb1f052d64a938e260795192a876f97bf34097eb
4380cb16e7415f58021fdf7dec9df8e521575b62d618bfc331b7efc3ea92394f73a0808d
f15e8794818649d9675edf3daaed3c5170a843d448bd1ec5d2e8e5dfd4254e334f4ad27d
73b614fe0f8542a0a644f6f824422e8e1e10cd125b9363da6f015354baa244921f8960eb
c44f97ad1a29330ac6adbce3269922e9a1990feb9e4c89a7e34368a04b79f5db62cda84a
f2ba028594de966674fa11ed21634922f8e5b4dbc0b9c9c899881dcaba8d6724d114b231
b1dc3088337a45070f5846c742f6184b0f0a1e55fe87bf37822cfc3ddb356c397ef85d9c
1c0c65db191a9d03469096c2ce42b919145708e3ee8b35e8d72db1c738d3a4389ae996f9
604ea6903e61ac0bbe56c8ba108cda00d1bdcc6904644705c9a858adc8cdc08f4449ef11
f4d0e28550586478ac6c8a8c8aed3927ca90e3b31fc8f5722aa68ad028642c14706b8ab0
e413201305f9f1a899f2ddd5fb6eff9985d0e57009956bc24f1d2c7b420eb3716a284df6
408e38cedc4c7ec1c11c205c8567cda8b12d4d8d97691015be532160a5a1731d8af5bd17
a35f0d958ca423abfd1c6346f9472ba7d7aa70b845ff343acdf9153aa939bcd101f0578f
afe84d4cc77c5b67eff3bdbc5bea27b703d4ca3cb5c4f4943855ff512517b2c57535bcc
7726e7c2cc739dc65cf805b018167ce1324ea5578f9af0378eb281c2a3b28fdab5775a42
49bbe587c06077eb20c1ddab672d4206cbcb0d48b461b92bdee4249408f132e3a36e63e8
ebd8dced63ef150da21c8264bdc65379a39f0331895e6d589444d9dbd56f7626252d7145
905dab7ed44ab0d14707fb1c19198196da8fc7388056a7a59fb0e19cc05d88ce6a60802c
73f9d785b48992318ae993397044f43c38709c319ef5a8e68a452bc5b79bd86ae50981e5
8f7cbc58c7e17946804ab019c18a570c499e8b425a600201ef63a40f7d918b60ec9eeba6
68201cdab4624c35fdc014cdfaf2e7749e056f195f1eefc1949420e5569c461bc26f888b
1aca0418552ad2dc1c5b62e6c972b60ba643344d52cbdade3286497595a5adc1c40d0f10
366cc9dbf9fb0e22445d5e7ba14c759fbfd1d4000000000000000000000000000000000
0006080f181f25",
"raw_public_key": "424b2f267e58d5b3b44d71acfc6a656bb26950d57c61db1c880
```

```
bcfa1feab443f0942ab8bdbad7d708abb356078f6d99a252271fe62c74091eb94afb9b9
264c50a888e0dfed80cd5fb2cbd3667e60d539ebe44930219cd4faed15dbb3455a264802
b9f49bce42ee7550feffdd4642a55ade693868a460cbec03f4fc99a4e30bccffa8a475e5
395396674eb81a94937587880f6dbd27bf1c4f5a9ee43cdd8b0e53b3b7fb49c73adfbcb
d4f8c54303520c29bf97e26ee57db342d957c893936522d0942b41d82ee3772a00570adf
b545c1143922b0496f826a0a970064b36ddf534b5f8e1c1cd0b5565ea846b45431f06181
43ece89777bb3f61179ad20295fe0a6e062ae6eecbc2ef38f2ac1a22dc93b7b126336223
c55b61eb8c0795542bbb2dc65e722eadc6866ffa9683beb8a999ad7a83e5e6e016c2e4c3
5f6f7649ad3bd52ec67ec1c5c6e7b9972771218be9554bba7727f0b84c44b9b0a8bd831f
cff2c9779ccd4ca30c6ad75b04983e41de893ee5f39ea7355180b709c7045c22d33a083f
6ae07a114746d1bfdccbee5b9043879bb5a2e120e2a4636283f4a1cd4924a2de6a4aa3d9
9ddd88f48aaa4e88bfd1ea769d82c10779f2ded796db542971ca289b76863ede5997b7e9
ce183b43ccec278b10d92b87442ce0435bb1625171db5554b470239c50d2a0c3a41b2a38
807db070b47bfb3e7d10f3cd979d69963c8d79f8029cc4a48eb04fcb3d708844febba8b6
dddf01ab64d59358e6505c4ec1d7cbb14ed2212df458ecef03fe03037b1505a4c944432
2f5f98dfa91a4cb8c45860a2dad7515350bb6d431e49a6bc8f5ba956e682b0e513321a9
7d1962602891c9078f62a8a9646a31387a6f09684264837899e0d8ec7d11c565901298b2
0b345081690eb4c562c1aa3a25bef06566cb34c79bc0b25e4095d6ba793e81311e41a332
9152686f00d4897f84fc4edf4b26d545365785ead8d63aef64a87c0b91a2e5500383956c
df5f6e37cf9d5482d1c8e3a5be38f17259ac45c9fa1c4bd3bf177d312ee52a6da023c057
22a8738274dda8d1b04e99831cf57c87282a256c565c296d0524a063a3a41a48a8300997
8d98d8abf61af68e8013b594fe151d9bec199902c4c70b49584201743c6b53103d2fd24b
df078dc90b5a188b4f8d772179988d0416c94d4c57c0860b9d7b53d4cd261f332a185156
5d52ac37f008747cafe320f363d9beb6e4117db43fd8aeebe5e0ce2f54e3f0367eb3cc97
1bbe0c301a8e52f96094936035c6ee3ca2d13db483a0dd04dc16247de0e0894ad7cb7e1a
e7ebd4f8f900582b20021e77f70254501c6ac3dd15d43bbb7931c5283244312158c2eb1b
3e1117e194f0a1e4c783efbc62c9f81c21562d0d34a5f042b5eaa32f31f95c5b055f4e7
a2070fb096f56c415549cde74f3864e8b9fc27e3299724b4639986044b55928fd6972785
b280c25a3e21aab814ecbf0c3cbec0914907ec907f25a1d88bce3d319ae8222a35945db
62af7cc75cd29c1f5d98fcb93f750dc3031076979bb51dfc37d23e8eea78073a24d3e26c
68e7bb10e459f2577b90080359ae0aec10318dcd9e0f9e34029c31b3e54b1855645db420
618783346dad5b55eddb4f977b326a655525ebe2195eca9cec38a3c0d2273b77d3e68f19
01c2ca5149734a51177bcb089476b18cba09fa8b9b46d94a2946f358e1dec1998652c58
a90852423e2c85e79d19724461627e6390d1a81fb1a72f9c7edc4bd747dd5c85217b5856
141028414ddb71458f0a0b2b589df2e1b051783b8f718676b1defbae98ba496c2a935e9
2eeadea0a8393ef59f9e914f0743fe65640ddf9981cea6dbdd957a534ad4e790efc974ee
89938ad99d53c5b680775399326834729bb37b082e795f8d87f52e6c8a8db68e515c277b
bea82a7570d4280896c987a0608903e306c632a223c55f0ea3682039c4a3f5440f4b5ac3
e6ed2b2dc900cecc72b72f50e49b2629ad30f0487b2707b86286f8c4f55659b25f9bdd7a
6af460cc3c57a3982663bb717461581e196894929d84153d87a7f482d284b5b894ce1a78
216b2a011f2b88742cee52d5133e8fe77edae242f5af91637c37ffca32430509b2fe4756
303a9a3659fe32528af1e10d8d43bea991b2d109786cc66d35b1d78df254b92cdaa40f91
a987e4a922ca81050e5bc3530ca85493bdf2a825374d0a8310a6860284ec3ec732326eee
ffc42bbd42bc91b73e5e7c6b599d016490637629f3876c3e42f8db590e66a85a7838c818
f78fff4853cbef09434989803545dca87657cf7c7e7e6afa71382bc10fa0bb6480f243e
ea1b86110100fa0cff3275621943cc58eb4dc3a0428a5e425670fe82268de71c511d8ff
bdc11b0d0f961120e971015ad5f448886b802e3fac11672319d487c84f1001339cb96978
4cb57344f2807f8b425f1d73caf8496d742ed237f4c9fcd5a4e84fba7e27fb1a8ae12c4f
0427ae24e910d951bd8c35d61f8a678db01caea8ef789a95b62ee1b8c5d32c6baa536ba8
8a1070ea61aabbf59294e3f6f974c4c91cafc5bbf6b7ecfd57a18fb7557d71e06e900d28
1b0b49aa00feabb35714af33870edd7ac2393d93177f79ee5606c9df176f025ce49a6e5f
f51a2a412ebf86ac0f40471c96ad4c119df230be6173df530ed656cbd8069214741ecdd0
271c603fb6c4a8614ff878d33e726cac6693e938ca3fba82c4995c14a2d4af9014fe4c4c
50b794cac596b52189f66a7106fb325b526ea"
}
```

Figure 7: ML\_DSA\_65







```
e4747e9825bfa336e5bbad14f73640f1b9febe800dbaefe1630c61fae635b074c564eaa9
db189c9e7302873fc64e6d497bc5c29080987a07a21d4af210703a4fa07f2fd816f12fd1
e29b4c0f44afe9bd4a1eaa8a7ae6f02a5b4258f52caf6127f62632a67cf4e8310be56a7c
28c86b2e277600c3e92c8d23d42586244c571e90568df202f2f6d81f860a565f9eb91a3c
78372e2a8b1be61c5418cf49bf2d6c8955d4a482a9919b7660b3f9a4404ffc454ea073e1
e4b2689ab2cca4e46bd7004a6c491fa26ee7a57d60f35edb2b821e6266442c8f335d452d
524c772e0353724c23c7dd15b7aa155e91442022140c5fcb0153147edcf3e8952f6f0399
a3c88066a72756c9409915de63f64fa797841c57c796c6fc550ef745dfe9f179457f9475
5ae5a2506a764f327e550be3dc14dd41f3b04b147d454938c63a8d69b2ea4c5710ec0b36
e3a6c72571fa5d59dde036c42033df35af056966ff0cd1204008971aa6ba9fb97b685ab9
ffa2a9d1778104cd2c3b326de1fcbcb242e94d0311c3275b12850ed30ceead3a2ee6d0605
08411d4396f5421d8b6d067cf7cb5e826785fbe119e05e21bd879b64f57cb0cd1972c281
5f20abe7ce6ab34d0f471af44baad179e90644122f5f33288e689dddc5ce833e9755df1
e73c65c5a201c4ede2ffa6b19274927719d2d38fdb7a65aa43708b7fa9a94aa7d3210253
d78d3b181e1020d000bd0a1dc05d447f9f58eb84c65b36c8afcb83727a1508994e826
957a663b0b9b8a003325ab6d6d6462ee4e106019c0dfffe10323b7bde7d82a38f85fd0878
6e860ba66c161b64b0708c363de5c6af62d8db3c243d1e1b712cb1d59e942b9b6b4295a5
a500b182cbd5fd1bc6ce9376d91b47a2284f1f0e0ad1c048cc2c2fbb4afa3a9eb9697503b
69fec990eba7e9441af9ca44cb3ac6b5ed66e591c201fe30efa8a7c471dc613d6254c26
3a8e132104bec47f1aacb3b2fcd4051b69b5e3fcb1c147a65c2f90c4b5188baf521cab0
3c12a309da50b5a7517727ed41228ed123fe1b152f6a6319cd623bf34ad7b8e064ab9932
60bcbd405f5b7fff9b2fa40ba5ed5630242539e5d96823e89dc818a13d16675ee3079d97
6f694f5acc9760ae789e9b3391b289e0e22a7ef17cc6a4577157b6d95c09baa4fd532e3e
e0a290810ed35e56bb19d9b61fb98a97c617425b06093d98a5cf0ee2dd127f0eea600b9a
0c67f7be761db9b77e5d5bba9701da1b883e521a0cfe88451f57bd36085b67e56f061f84a
2e6a152a71bce6e522daab6a0a33ce22e537fa9793d28b617e6c0a4176a83aa3be578afa
c0f2f5547c5516d218984755b7445c7143afa4e551f0e071bdb873b34e6b9e2b9e79ed0
c69d288ed6421f237e860a0c6492ebbdd2a44c2c4f368db99941b1e8561d859d3859f49
6cee3d741f252973f8fcc539c409e35cc80a5ed6df23cc3a65601313f5d681fd9540c529
1a9e30a72e38c96413c47c61ff84fde78d011b01b4154d1b920af003f7abb1e1999dea6a
766cf9fd2702b3ce0ee57af931b62124b0861b163a3b91aa4bea28076c3432df3b29b6c4
e1ba588def420071fc157de90eb272ecc9ab00df3c669383a61a91bb67bd287ce349b47
45ee7a479dbceef166b9acc412eb579fcd6437307edda253d606b7be7599c38092bc52a8
598480edab8b82b1d21c565d2137ceae0b6642619b16133d91205d6355029e9cdf9e9a28
b373d95916b6b707d4c712c09cf36daf1a511b2bedb1aa70ee58d46a0666bb287784b0a3
840c589a7a04d5d6f2216be90aa4a512d5632f5c9bfe7b8b13382f999b95d367c7c46b96
8074ce315197a5fff3545c7b77a804ade56a95b5c24cdece5937b5c0366d93ad03da9bc5d
b1b551dfb91e9b343d2b57b763439686d4a3', -2: h'00000000000000000000000000
000000000000000000000000000000000000000000000000000000000000000000000000
"sign1": "d2845827a2013831045820d9bc439f97bd6d4093e68f0f3fcf09c9a97adf
888ed7308dd565247a166cb4faa0581d68656c6c6f20706f7374207175616e74756d2073
69676e617475726573591213e132b492fc022d5fd1d2205f52dbf1ad1aaef3eace4622b4e
3875696d64d66dccc74df743c1b85552a0f3c1bdaaa8f789a15fdb3ce6329021f5815316
cda1da5b012f1ccea4a47ef7e93eff319048ac9e3b6ed46cd58c6557af1b340da3bd7966
f1588f8bd88e05383aee12a7248db3aec96ba5d9afd1d79d62865eee04cac9cc2176ae58
5ae914d614805d916c142b4969be7ad95a44bf9c154d19bd41d8a3882ad6f0b0802d1e03
7c7579453a0606bbb31db164fc607646477572c63b71720f8d47bbb7615dd264f5829f7
26e22740cb3a1e1b5e381c4f692f7ecaa0979ae17aea3139d733491fe213eeddc5f68e0
6ee71b80f14ed693f407ce6e199cb3edb048d3e2905ce75b31bd6837a1d4b5eeffa35431d
0ca407200e60768b2dc5b0370e91a6c03c3d0e5c47225616034f55fb0a30a66fd2074847
be3c1230b93650d119492efc20338af0c4cb6a176191d7c5bbc7427f6f0c9bb49a0d73e7
f026cf3855547fc7ca9369733313963ffe4647e155a93cfa5403edebfc7842e75dad9ae2
accba720487e476ffe3bc0a60cf32271429242023d0d0a8f6e4e77a874afd2074a11ff20
bae28d00fd5d990f839ca99c6db28a55da94a785290a6b536893a237224639717ba5cf83
3d57db2cca0a7aeed874597c6ee71e0dc35e06851e9d2bd022c37b5fbcd2a4d5e8daea9
8a44cb9c97df43a0aa512005358c8d5d5db88fba610e47d5a863f53f9ec7a8f3cb0b0ec2
f02b1dfe9867a1437e84e941392b149275e868b959c58b9e814fb618c61208cb68388124
7bb0dcab96e84a77e0195b4e93f693c1e98dcb99e495632f6cd5839d3bcccdfa2bf6b269
```

21759d0a293595a96e6ddd42c83d8d9a7b10a001b34f47c20fd46d1e09100e532e5b1900  
b89f14400bbcdd5ee0cf61a1ca353398a498da488b0f117effcf999f5aafe4a587deaa3f  
f78cc431637adcb4e40ec385fac23e8176b74e0e750460f7d2002bf7465944caa270883  
5d3849199732090b7c514575311ef9999c9bfcf737a4d906af914d0507f5a7c2e61ff123  
59999d173f88db9ef85a6d71ac2e3a8074bed9472e00aedac26c48ab9c2d1ad96eef6e6e  
200686efa17086317a541ffad5c8b5707279aebc12ca48f7e7d755e8cdc2bc990c6391ab  
f9351c2f5305bda2c57bf54e419dce477947a64de07eb0432e5f1cc87234ed673fa810d5  
62095d0d0eed260bef5fc3daed8506756acb9059257b025471d8df2d4e697a3e7c74c470  
81b569519e1de636a971668a376b4d84d95c30a554894475be8f01bda7c6d78989572aea  
4c4e976a408b4a04b406e79e176163dcc1ffa7a7e9bd6ef6f854128097aa760ed3d6ad27  
9f7ea4ad6003f43cfb75de79c0bf8113a6f788e35e92f30185695f4abb18e924b29abf21  
8e708977cb2776a7abf46a41e46afe24863eed4fe890916f95d5b1f6e6cea096ceb4ad47  
8fc994214f59c5e68c8b9695c27f8fada32c90ed324925540912da750451f03335917757  
9e4e4a04e5d5b9bfa72616df63df20f17038e7d4bbe61562583046c35e3a71a0f596f119  
ef183786ed76e1da6d3be98277db1583c8f2c8784c08f5c098abfd31baa9fc6abd0cc44  
1b6f93961b6630c45b9e7dda60d88be7c9577b6fbc5edf65de4ed0b53f4377ce83b1e55c  
4d62015569b96ea094644e0f9cbe89cff4c539f77c629a5101c259c56cb9d31e20160dfe  
28386b37e610c2db9ecf6a000bfb2a85756e585ae6b97915e5113970946df068e6da7f0a  
f0a48802b9e0464bfac7e0c6b7dee953665061ac7486d9eee3bf21137383e97eb393a708  
e91a94f5012fa1d072c04f5c5ca2bbf894e7b275805fe5d81341d75b9f7fcb89b3ff7da2  
b623c35d717d0da7180e258384ff39a914c2f30f893af4e1520d64a15bb0997b852f3ec6  
ca398d245361fc2297c83867f388c8aa35e704d3f7081a961c528751faa64fd7efbcc03b  
ed69e99ae1517d499117227cb08254d7b8aa079530af39fb19b246d45a4d41a995509563  
6c786dcc3c30c817ee3c8e60689fd9a494c9e774463df7b884a78dfe80f1e247b3f12240  
1b0834e54fdeb57d7835f0409126983e40d8922bbd54981e2b651cc3fdee9193468c0412  
01c2c472749300250628225052f935d37ab9dd8e466b6a3acb63ee93023013443ddeb913  
47b84eb6ecf37423996d682967a5aab7ccaaa73a690a9cbd45b15ee38f2ae698aac3cb21  
17ecc9160870993a3e50ea7647b0c03cb5f6daa290492dd693a0b8a9a9759d0d977b662d  
45c4af5dce95084062f7a0f39d0bc3bdabaa31d8f815047244303e6a6e5d977ec757a567  
97f0630ef1d4f02f7a0e7680c0865c4404c97bbf7014bfa64d0f89b02a2b981f616c0e16  
090c4b7fe9998a0232469b0c059d3daf58af6148cee567e52f1a41730b28d6af79358ad  
3679cf4c3dec0df780eccc91d004a4ec0a4d20cc6771dbb3f42da69dc2140994c228a60a  
dc0e97438a2332db657e91e5b7f5029541d13ce8456d93bb4933522c94e16ee4766af28b  
5754b5a74c71efb6fff445dc1aed5f3e21cfe512cf9862489582925c763251376279f69e6  
33a43aaadcfc4c104744cfca747f477c1af8c18f65109b06680cd392d14e3e0ed0ba11764  
3c8794bc8d036e85222d543063a01f91cb9bceb80d884b1305d0065ef3555d6f64be4893  
816e0e9be111c65c9cb1840774ddd4ed5906ae2a73c7ca6103ecd3bb506747681e192dd6  
c259b66dc63c39dbdc33dac1d564b54db4d8de935370abca642e05c6e95ee827fb71d608  
6691bc6d1be2a0c7e491ce22163d3e8d48541cd7aca76eccc93f4e02ac0179cf7073d500  
0b3ff338d096bc87eada3f4019dfd1a5d12470a33f65c2990c217680710069de75e0338d  
1e26c179b1cf9ef853edaaab2c0519026b3d9f574b82b5bd316686b26c9e9e87870041fd  
fa1a5c538cb98cb39200856b4c9bdacaa1c7717a22b883c06ca0f78229cd59362614361c  
c5ec76d836d2dafc1ed51066afa7297db869508cc80543b1efcddc62eb7c4ffabe3fafbc  
02f4802b4992ff0be194ae123880ceee6187e08c7db96b22438ac4bdabadd8aba7af68b8  
e2ac0c60c0f9aad5e4e1bf886db18212e9cb46d8bc201e4a1a6fb231d91a309dbca30b6b  
1269ec31bda1bb6b6d8ff41d84baf7db7ac30de5ad5d9259398bbfb5ffbb89cce88a15f0  
f7413c9c71487b56eea23573697a583fa57d3537588ba5558363d8abd679f2968dbca3ff  
00b141d68d5baed53fa66480029f46f6b195e3dc99a0e09f990841c62735db8e4b6b867e  
e416cd946b65fae48acd2c580c5ee461fdc78c2d671abb657f9296f976cb74c02249676a1  
11e7608785ede2acde6f8af297f88ce9ad0e6b4cfdac1c586519042ac700a4178f5c23ad  
d6634c26588f47bf7ec9e244ae8c71382042c24606410ef598ccfcaa459923e748d608c  
af3c82dd141c8eb32a500a03bb7fbd5d628b625fec3d9399254d7c569ab1418c6af0db6  
4009f09d457e287b0e8b83bf40d529379464df999d7519a454bb3fa9684f398c965c4f98  
0061d33fd8883c5ad2964806f27fdfb09458b1bb2daaced0fbc0c68d46d62224f6372593  
2b58ae0a694ec7fa0d4e5fcdc75840b467e12514f1cd006befcf3410cf7a5c81adf3d29c  
d93ef5680c1a953daa0645273d0f5fcdc8e6e0f8c632b67a674fb4f390c392720ec6d8e3f  
1234e84f8420b91217ad71f406b1a4c7f2c438ffff7844a097cdfb00a2f1a94ee6bdd5977  
56a754681111d66040c13a661b978440b05ba8c16e2a4255ebff56e5adada6fb92292d50



15316cda1da5b012f1ccea4a47ef7e93efff319048ac9e3b6ed46cd58c6557af1b340da3b  
d7966f1588f8bd88e05383aee12a7248db3aec96ba5d9afd1d79d62865eee04cac9cc217  
6ae585ae914d614805d916c142b4969be7ad95a44bf9c154d19bd41d8a3882ad6f0b0802  
d1e037c7579453a0606b31db164fc607646477572c63b71720f8d47bbb7615dd264f5  
829f726e22740cb3a1e1b5e381c4f692f7ecaa0979ae17aea3139d733491fe213eeddc5  
f68e06ee71b80f14ed693f407ce6e199cb3edb048d3e2905ce75b31bd6837a1d4b5eefa3  
5431d0ca407200e60768b2dc5b0370e91a6c03c3d0e5c47225616034f55fb0a30a66fd20  
74847be3c1230b93650d119492efc20338af0c4cb6a176191d7c5bbc7427f6f0c9bb49a0  
d73e7f026cf3855547fc7ca9369733313963ffe4647e155a93cfa5403edebfc7842e75da  
d9ae2accba720487e476ffe3bc0a60cf32271429242023d0d0a8f6e4e77a874afd2074a1  
1ff20bae28d00fd5d990f839ca99c6db28a55da94a785290a6b536893a237224639717ba  
5cf833d57db2cca0a7aeed874597c6ee71e0dc35e06851e9d2bd022c37b5fbcd2a4d5e8  
daea98a44cb9c97df43a0aa512005358c8d5d5db88fba610e47d5a863f53f9ec7a8f3cb0  
b0ec2f02b1dfe9867a1437e84e941392b149275e868b959c58b9e814fb618c61208cb683  
881247bb0dcab96e84a77e0195b4e93f693c1e98dcb99e495632f6cd5839d3bcccdfa2bf  
6b26921759d0a293595a96e6ddd42c83d8d9a7b10a001b34f47c20fd46d1e09100e532e5  
b1900b89f14400bbcdd5ee0cf61a1ca353398a498da488b0f117effcf999f5aafe4a587d  
eaa3ff78cc431637adcbb4e40ec385fac23e8176b74e0e750460f7d2002bf7465944caa2  
708835d3849199732090b7c514575311ef9999c9bfcf737a4d906af914d0507f5a7c2e61  
ff12359999d173f88db9ef85a6d71ac2e3a8074bed9472e00aedac26c48ab9c2d1ad96ee  
ffe6e200686efa17086317a541ffad5c8b5707279aecb12ca48f7e7d755e8cdc2bc990c6  
391abf9351c2f5305bda2c57bf54e419dce477947a64de07eb0432e5f1cc87234ed673fa  
810d562095d0d0eed260bef5fc3daed8506756acb9059257b025471d8df2d4e697a3e7c7  
4c47081b569519e1de636a971668a376b4d84d95c30a554894475be8f01bda7c6d789895  
72aea4c4e976a408b4a04b406e79e176163dcc1ffa7a7e9bd6ef6f854128097aa760ed3d  
6ad279f7ea4ad6003f43cfb75de79c0b8113a6f788e35e92f30185695f4abb18e924b29  
abf218e708977cb2776a7abf46a41e46afe24863eed4fe890916f95d5b1fbe6cea096ceb  
4ad478fc994214f59c5e68c8b9695c27f8fada32c90ed324925540912da750451f033359  
177579e4e4a04e5d5b9bfa72616df63df20f17038e7d4bbe61562583046c35e3a71a0f59  
6f119ef183786ed76e1da6d3be98277db1583c8f2c8784c08f5c098abfd31baa9fc6abdc  
0cc441b6f93961b6630c45b9e7dda60d88be7c9577b6fbc5edf65de4ed0b53f4377ce83b  
1e55c4d62015569b96ea094644e0f9cbe89cfff4c539f77c629a5101c259c56cb9d31e201  
60dfe28386b37e610c2db9ecf6a000bfb2a85756e585ae6b97915e5113970946df068e6d  
a7f0af0a48802b9e0464bfac7e0c6b7dee953665061ac7486d9eee3bf21137383e97eb39  
3a708e91a94f5012fa1d072c04f5c5ca2bbf894e7b275805fe5d81341d75b9f7fcb89b3f  
f7da2b623c35d717d0da7180e258384ff39a914c2f30f893af4e1520d64a15bb0997b852  
f3ec6ca398d245361fc2297c83867f388c8aa35e704d3f7081a961c528751faa64fd7efb  
cc03bed69e99ae1517d499117227cb08254d7b8aa079530af39fb19b246d45a4d41a9955  
095636c786dcc3c30c817ee3c8e60689fd9a49c49e774463df7b884a78dfe80f1e247b3f  
122401b0834e54fdeb57d7835f0409126983e40d8922bbd54981e2b651cc3fdee9193468  
c041201c2c472749300250628225052f935d37ab9dd8e466b6a3acb63ee93023013443dd  
eb91347b84eb6ecf37423996d682967a5aab7ccaaa73a690a9cbd45b15ee38f2ae698aac  
3cb2117ecc9160870993a3e50ea7647b0c03cb5f6daa290492dd693a0b8a9a9759d0d977  
b662d45c4af5dce95084062f7a0f39d0bc3bdabaa31d8f815047244303e6a6e5d977ec75  
7a56797f0630ef1d4f02f7a0e7680c0865c4404c97bbf7014bfa64d0f89b02a2b981f616  
c0e16090c4b7fe9998a0232469b0c059d3daff58af6148cee567e52f1a41730b28d6af79  
358ad3679cf4c3dec0df780ecc91d004a4ec0a4d20cc6771dbb3f42da69dc2140994c22  
8a60adc0e97438a2332db657e91e5b7f5029541d13ce8456d93bb4933522c94e16ee4766  
af28b5754b5a74c71efb6ff445dc1aed5f3e21cfe512cf9862489582925c763251376279  
f69e633a43aaadcf4c104744cfca747f477c1af8c18f65109b06680cd392d14e3e0ed0ba  
117643c8794bc8d036e85222d543063a0f191cb9bceb80d884b1305d0065ef3555d6f64b  
e4893816e0e9be111c65c9cb1840774ddd4ed5906ae2a73c7ca6103ecd3bb506747681e1  
92dd6c259b66dc63c39dbdc33dac1d564b54db4d8de935370abca642e05c6e95ee827fb7  
1d6086691bc6d1be2a0c7e491ce22163d3e8d48541cd7aca76eecc93f4e02ac0179cf707  
3d5000b3ff338d096bc87eada3f4019fdf1a5d12470a33f65c2990c217680710069de75e  
0338d1e26c179b1cf9ef853edaaab2c0519026b3d9f574b82b5bd316686b26c9e9e87870  
041fdfa1a5c538cb98cb39200856b4c9bdacaa1c7717a22b883c06ca0f78229cd5936261  
4361cc5ec76d836d2dafc1ed51066afa7297db869508cc80543b1efcddc62eb7c4ffabe3

fafbc02f4802b4992ff0be194ae123880ceee6187e08c7db96b22438ac4bdabadd8aba7a  
f68b8e2ac0c60c0f9aad5e4e1bf886db18212e9cb46d8bc201e4a1a6fb231d91a309dbca  
30b6b1269ec31bda1bb6b6d8ff41d84baf7db7ac30de5ad5d9259398bbfb5ffbb89cce88  
a15f0f7413c9c71487b56eea23573697a583fa57d3537588ba5558363d8abd679f2968db  
ca3ff00b141d68d5baed53fa66480029f46f6b195e3dc99a0e09f990841c62735db8e4b6  
b867ee416cd946b65fae48acd2c580c5ee461fdc78c2d671abb657f9296f976cb74c0249  
676a111e7608785ede2acde6f8af297f88ce9ad0e6b4cfdac1c586519042ac700a4178f5  
c23add6634c26588f47bfb7ec9e244ae8c71382042c24606410ef598ccfcaa459923e748  
d608caf3c82dd141c8eb32a500a03bb7fbd5d628b625fec3d9399254d7c569ab1418c6a  
f0db64009f09d457e287b0e8b83bf40d529379464df999d7519a454bb3fa9684f398c965  
c4f980061d33fd8883c5ad2964806f27fdfb09458b1bb2daaced0fbc0c68d46d62224f63  
725932b58ae0a694ec7fa0d4e5fcdc75840b467e12514f1cd006befcf3410cf7a5c81adf  
3d29cd93ef5680c1a953daa0645273d0f5fdc8e6e0f8c632b67a674fb4f390c392720ec6  
d8e3f1234e84f8420b91217ad71f406b1a4c7f2c438fff7844a097cdfb00a2f1a94ee6bd  
d597756a754681111d66040c13a661b978440b05ba8c16e2a4255ebff56e5adada6fb922  
92d501d30e351f4fb5b907d9f1510e9801489da0a3cf4997eed6df4fb06b86f81af37357  
81513c6654e030a03e358970fa129fdb8cb49365a86f1cdd1a9b5f966794c8bca163c3af  
148406c24f0e149da338e6a1fb5f365b1a6bf0fe426ec424823588dce11dfe7de3b3aa74  
0d27fac9b6d9c60909b4afe2f88dde858069e330e6f9a7ecc779022d3925ea0bd73e6704  
1945e04691152683453f3126cb3699b607dd598af05fd441c157bb3b8d69243705cd1e71  
442b502b7ea987c8837a3bd896e5bf2796052a23d302c70b23a62383278e1f3c878c2bdc  
b68524c078fc73148f227951566c19248240d972d5547350909c63d6f505ad889884f9c7  
10154d2ec05aa15a4f734e5b88480916ec73e1518fbd2605954580ec2b0a8f9c4bd4d075  
461b6b3015c344e83382c36b161e57a6c3933e98209ce308190531f85f5d5fd9451d37f4  
0f6f36af830b376ed2d48ab20b2b58b7c6e5956b7d4142b19ccb19a88db70e5829047751  
950e2975bb4d0e9991fc3bbc4fa5adf2d9d1e25e4ded5396731bd2808b8227a30233cc7a  
1ab7759623357547e46060a4c6c54a8d24116680186ca97291afd2be4ffdc9bea1c4b81a  
d80a3e7be17fb5585eeb72dfc030655040993fe12f58d21d3ea499c1ecac70725f2e1334  
50e9c1e75ce657300f85ae0f44e470336dbd5df32fbc0a8ffbe3c66058e45ac5fb0ea388  
9313214b6b2ec98a91e6414b3dda04d9c41857707bbdcf4763ee3846c7f4df034e1dc8fe  
fc8a2a5dcd9f91940cdcd1f7b98b93c08bc9f1c198e80fcd8e8a5effe4ea4363a56cae57  
de4a7248fd8bde5767f1ae699b5bd998d9f613306346472e96954dc32bacd31c3f44b0f  
11b8e6810bb3f27af7de6a57550288f56015b1b76f1c1e492d5b998493b72a38ba4f2619  
b891aaccfd96c27fe80b958e08728581ca4d6e7da5f2760b48734a049e8fb29aa6fff3739  
11d712091ef6bbbed204da3b1237c1195654c7f66aa6776e950e7a27aed6c9a4fffebe7667  
1ff1dea7b1ee5d0434c976d2d23bb481b6d80d242a2c942329dbe051396d0a9add080686  
34f6c7f8aadfd55e4109cde60f693229f605d71f896f5e1c9d3b94fb9a497a9b95596030  
7811296f2ed263ad57780c6f2f96b42eb71e817bbbed0654000c6bc20d3087f7971b8d517  
c00cdf9732294285c6faa24b405e3b31e6fb856b57aabae81e72a8876f06cc0fbd5ca44  
79a5cecddee7b5bd0fff8f8c788e2d803dad28ca110f6013672323540b94eb5a7638116cf  
ec790f2d899d7f6bc075cbb78ad925845bc75b8086078356b0c6dc722283e774cb7a5ee2  
4a6b976ca6dcc40fef3ea10e77cc50a0523ab4df32971a19c9c6e889edb99ea9d863e7f9  
922d02303b80a29899397f4abacc5ecf6da98574e2ee2afcd18077063d7419e4ee361891  
085217c905f6cefb2041ee6f49df051511152f45609a0d06d951b0351431651bde5b5434  
c06b146509727cd5b76f182c1353ee94e6ef98901cdba4b6cfc1dda01628ff86b21e2be5  
3da4a8c2c9fc1b50b28ada2836959ed1398c70018b5f3c35d9f3c8768af0966a0e8ee6b1  
6dd17455acecd377fd259379e7e22f187876db740c3c09a0307891484f9b12da66916d9d  
4018ac34b9d70a094a655ece0282839a9e60b8cea041316803b262a4928d375889017f3d  
a58b9721ac9d7a4e69b06fb26d46a904b062728286ee2e44c18354be39252482e5135fbf  
d1ea4f85dfc96b63e0fc8815a3a0f1be7476e60712a566911663159e74838f27a0068b21  
31aec8653b5f697ede4dd8c769234ba5d018ede320aeace49e263844b93d3c2410af9c5d  
f83c0e7eb617930eea8a272e16a6d58e6ce1ce9a3b42ad94436abe73e01b95839038d543  
0676ef6a7a3c77cd541fe860d40bd9414133a8983280e139161d85dc0c395eac1ffc6fe5  
2d637fd5f327d112f8ed15172925b0a21334d8b5dbeaea1bdbfcf9bcb8c9bd72b58aa674  
5f07fae50343191f90983e4d138a278f46433a8c404565c4d15a55c4d61f396444b639bf  
7191515c558155bf2a09576e7b3376236a23baeb2f7826e1b5e95e100bae7d0b92268648  
39d04f2145cf0a0c0dbb0194f2224aa63cb144a0038cd63ac6b42bd9c74e7d1eff9cc141  
9043a8bbec602e5665d45ddfa09c1831c0c04fa116ff8ad7fd93a0d005dedb329407c84b



c9160870993a3e50ea7647b0c03cb5f6daa290492dd693a0b8a9a9759d0d977b662d45c4  
af5dce95084062f7a0f39d0bc3bdabaa31d8f815047244303e6a6e5d977ec757a56797f0  
630ef1d4f02f7a0e7680c0865c4404c97bbf7014bfa64d0f89b02a2b981f616c0e16090c  
4b7fe9998a0232469b0c059d3daff58af6148cee567e52f1a41730b28d6af79358ad3679  
cf4c3dec0df780ecc91d004a4ec0a4d20cc6771dbb3f42da69dc2140994c228a60adc0e  
97438a2332db657e91e5b7f5029541d13ce8456d93bb4933522c94e16ee4766af28b5754  
b5a74c71efb6ff445dc1aed5f3e21cfe512cf9862489582925c763251376279f69e633a4  
3aaadcfc4c104744cfca747f477c1af8c18f65109b06680cd392d14e3e0ed0ba117643c87  
94bc8d036e85222d543063a01f91cb9bceb80d884b1305d0065ef3555d6f64be4893816e  
0e9be111c65c9cb1840774ddd4ed5906ae2a73c7ca6103ecd3bb506747681e192dd6c259  
b66dc63c39dbdc33dac1d564b54bd4d8de935370abca642e05c6e95ee827fb71d6086691  
bc6d1be2a0c7e491ce22163d3e8d48541cd7aca76eecc93f4e02ac0179cf7073d5000b3f  
f338d096bc87eada3f4019fdf1a5d12470a33f65c2990c217680710069de75e0338d1e26  
c179b1cf9ef853edaaab2c0519026b3d9f574b82b5bd316686b26c9e9e87870041fdfa1a  
5c538cb98cb39200856b4c9bdacaa1c7717a22b883c06ca0f78229cd59362614361cc5ec  
76d836d2dafc1ed51066afa7297db869508cc80543b1efcddc62eb7c4ffabe3fafbc02f4  
802b4992ff0be194ae123880ceee6187e08c7db96b22438ac4bdabadd8aba7af68b8e2ac  
0c60c0f9aad5e4e1bf886db18212e9cb46d8bc201e4a1a6fb231d91a309dbca30b6b1269  
ec31bda1bb6b6d8ff41d84baf7db7ac30de5ad5d9259398bbfb5fbb89cce88a15f0f741  
3c9c71487b56eea23573697a583fa57d3537588ba5558363d8abd679f2968dbca3ff00b1  
41d68d5baed53fa66480029f46f6b195e3dc99a0e09f990841c62735db8e4b6b867ee416  
cd946b65fae48acd2c580c5ee461fdc78c2d671abb657f9296f976cb74c0249676a111e7  
608785ede2acde6f8af297f88ce9ad0e6b4cfdac1c586519042ac700a4178f5c23add663  
4c26588f47bfb7ec9e244ae8c71382042c24606410ef598ccfcaa459923e748d608caf3c  
82dd141c8eb32a500a03bb7fbd5d628b625fec3d9399254d7c569ab1418c6af0db64009  
f09d457e287b0e8b83bf40d529379464df999d7519a454bb3fa9684f398c965c4f980061  
d33fd8883c5ad2964806f27dfdb09458b1bb2daaced0fbc0c68d46d62224f63725932b58  
ae0a694ec7fa0d4e5fcd75840b467e12514f1cd006befcf3410cf7a5c81adf3d29cd93e  
f5680c1a953daa0645273d0f5fdc8e6e0f8c632b67a674fb4f390c392720ec6d8e3f1234  
e84f8420b91217ad71f406b1a4c7f2c438fff7844a097cdfb00a2f1a94ee6bdd597756a7  
54681111d66040c13a661b978440b05ba8c16e2a4255ebff56e5adada6fb92292d501d30  
e351f4fb5b907d9f1510e9801489da0a3cf4997eed6df4fb06b86f81af373f40f6f36af8  
4e030a03e358970fa129fdb8cb49365a86f1cdd1a9b5f966794c8bca163c3af148406c24  
f0e149da338e6a1fb5f365b1a6bf0fe426ec424823588dce11dfe7de3b3aa740d27fac9b  
6d9c60909b4afe2f88dde858069e330e6f9a7ecc779022d3925ea0bd73e67041945e0469  
1152683453f3126cb3699b607dd598af05fd441c157bb3b8d69243705cd1e71442b502b7  
ea987c8837a3bd896e5bf2796052a23d302c70b23a62383278e1f3c878c2bdcb68524c07  
8fc73148f227951566c19248240d972d5547350909c63d6f505ad889884fe9710154d2ec  
05aa15a4f734e5b88480916ec73e1518fbd2605954580ec2b0a8f9c4bd4d075461b6b301  
5c344e83382c36b161e57a6c3933e98209ce308190531f85f5d5fd9451d37f40f6f36af8  
30b376ed2d48ab20b2b58b7c6e5956b7d4142b19ccb19a88db70e5829047751950e2975b  
b4d0e9991fc3bbc4fa5adf2d9d1e25e4ded5396731bd2808b8227a30233cc7a1ab775962  
3357547e46060a4c6c54a8d24116680186ca97291afd2be4ffdc9bea1c4b81ad80a3e7be  
17fb5585eeb72dfc030655040993fe12f58d21d3ea499c1ecac70725f2e133450e9c1e75  
ce657300f85ae0f44e470336dbd5df32fbc0a8ffbe3c66058e45ac5fb0ea3889313214b6  
b2ec98a91e6414b3dda04d9c41857707bbdcf4763ee3846c7f4df034e1dc8fefc8a2a5dc  
da9f91940cdcd1f7b98b93c08bc9f1c198e80fcde8a5effe4ea4363a56cae57de4a7248f  
d8bde5767f1ae699b5bd998d9f613306346472e96954dc32baccd31c3f44b0f11b8e6810  
bb3f27af7de6a57550288f56015b1b76f1c1e492d5b998493b72a38ba4f2619b891aeccf  
d96c27fe80b958e08728581ca4d6e7da5f2760b48734a049e8fb29aa6ff373911d712091  
ef6bbbed204da3b1237c1195654c7f66aa6776e950e7a27aed6c9a4ffebef76671ff1dea7b  
1ee5d0434c976d2d23bb481b6d80d242a2c942329dbe051396d0a9add08068634f6c7f8a  
adfd55e4109cde60f693229f605d71f896f5e1c9d3b94fb9a497a9b955960307811296f2  
ed263ad57780c6f2f96b42eb71e817bbcd0654000c6bc20d3087f7971b8d517c00cdf973  
2294285c6faa24b405e3b31e6fb856b57aabae81e72a8876f06cc0fbda5ca4479a5cecede  
e7b5bd0fff8f8c788e2d803dad28ca110f6013672323540b94eb5a7638116cfec790f2d8  
99d7f6bc075cbb78ad925845bc75b8086078356b0c6dc722283e774cb7a5ee24a6b976ca  
6dcc40fef3ea10e77cc50a0523ab4df32971a19c9c6e889edb99ea9d863e7f9922d02303



```
fb923d8573148990cd2ef133c78ceecab72ed9dd285c5a3766852d54534207ffd34027f6
c76ede8fd1a32d72c30048bbaa797d5df6fde27d087de5721ad7b7fa3e8d3f70d6bfc3ab
2e252335368bbfa15acb5cb37d4694e8b23cebe25de9c925a221a183b904d3f85df9929a
919c54d6f87457373a0d6ecc1403e4cbbe620999435e80696634cd1a8e4747e9825bfa33
6e5bbad14f73640f1b9febe800dbaefe1630c61fae635b074c564eaa9db189c9e7302873
fc64e6d497bc5c29080987a07a21d4af210703a4fa07f2fd816f12fd1e29b4c0f44afe9b
d4a1eaa8a7ae6f02a5b4258f52caf6127f62632a67cf4e8310be56a7c28c86b2e277600c
3e92c8d23d42586244c571e90568df202f2f6d81f860a565f9eb91a3c78372e2a8b1be61
c5418cf49bf2d6c8955d4a482a9919b7660b3f9a4404ffc454ea073e1e4b2689ab2cca4e
46bd7004a6c491fa26ee7a57d60f35edb2b821e6266442c8f335d452d524c772e0353724
c23c7dd15b7aa155e91442022140c5fcb0153147edcf3e8952f6f0399a3c88066a72756c
9409915de63f64fa797841c57c796c6fc550ef745dfe9f179457f94755ae5a2506a764f3
27e550be3dc14dd41f3b04b147d454938c63a8d69b2ea4c5710ec0b36e3a6c72571fa5d5
9dde036c42033df35af056966ff0cd1204008971aa6ba9fb97b685ab9ffa2a9d1778104c
d2c3b326de1fcbcb242e94d0311c3275b12850ed30ceead3a2ee6d060508411d4396f5421
d8b6d067cf7cb5e826785f5e119e05e21bd879b64f57cb0cd1972c2815f20abe7ce6ab34
d0f471af44baad179e90644122f5f33288e689ddddd5ce833e9755df1e73c65c5a201c4e
de2ffa6b19274927719d2d38fdb7a65aa43708b7fa9a94aa7d3210253d78d3b181e1020d
0000bd0a1dc05d447f9f58eb84c65b36c8afcb83727a1508994e826957a663b0b9b8a0
03325ab6d6d6462ee4e106019c0dfffe10323b7bde7d82a38f85fd08786e860ba66c161b6
4b0708c363de5c6af62d8db3c243d1e1b712cb1d59e942b9b6b4295a5a500b182cbd5fd1
bc6ce9376d91b47a2284f1f0ad1c048cc2cfbb4afa3a9eb9697503b69feca990eba7e9
441af9ca44cb3ac6b5ed66e591c201fe30efa8a7c471dc613d6254c263a8e132104bec47
f1aacb3b2fcd4051b69b5e3fcb1c147a65c2f90c4b5188bafc521cab03c12a309da50b5a
7517727ed41228ed123fe1b152f6a6319cd623bf34ad7b8e064ab993260bcbd405f5b7ff
f9b2fa40ba5ed5630242539e5d96823e89dc818a13d16675ee3079d976f694f5acc9760a
e789e9b3391b289e0e22a7ef17cc6a4577157b6d95c09baa4fd532e3ee0a290810ed35e5
6bb19d9b61fb98a97c617425b06093d98a5cf0ee2dd127f0eea600b9a0c67f7be761db9b7
7e5d5bba9701da1b883e521a0cfe88451f57bd36085b67e56f061f84a2e6a152a71bce6e
522daab6a0a33ce22e537fa9793d28b617e6c0a4176a83aa3be578afac0f2f5547c5516d
218984755b7445c7143afa4e551fce0071bdb873b34e6b9e2b9e79ed0c69d288ed6421f2
37e860a0c6492ebbdd2a44c2c4f368dbe99941b1e8561d859d3859f496cee3d741f25297
3f8fcc539c409e35cc80a5ed6df23cc3a65601313f5d681fd9540c5291a9e30a72e38c96
413c47c61ff84fde78d011b01b4154d1b920af003f7abb1e1999dea6a766cf9fd2702b3c
e0ee57af931b62124b0861b163a3b91aa4bea28076c3432df3b29b6c4e1ba588def42007
1fc157de90eb2722ecc9ab00df3c669383a61a91bb67bd287ce349b4745ee7a479dbceef
166b9acc412eb579fcd6437307edda253d606b7be7599c38092bc52a8598480edab8b82b
1d21c565d2137ceae0b6642619b16133d91205d6355029e9cdf9a28b373d95916b6b70
7d4c712c09cf36daf1a511b2bedb1aa70ee58d46a0666bb287784b0a3840c589a7a04d5d
6f2216be90aa4a512d5632f5c9bfe7b8b13382f999b95d367c7c46b968074ce315197a5f
f3545c7b77a804ade56a95b5c24cdece5937b5c0366d93ad03da9bc5db1b551dfb91e9b3
43d2b57b763439686d4a3"
}
```

Figure 8: ML\_DSA\_87

## Acknowledgments

We would like to thank Simo Sorce, Ilari Liusvaara, Neil Madden, Anders Rundgren, David Waite, Russ Housley, Filip Skokan, Peter Yee, and Lucas Prabel for their comments and reviews of this document.

## Contributors

**Rafael Misoczki**

Google

Email: [rafaelmisoczki@google.com](mailto:rafaelmisoczki@google.com)**Michael Osborne**

IBM

Email: [osb@zurich.ibm.com](mailto:osb@zurich.ibm.com)**Christine Cloostermans**

NXP

Email: [christine.cloostermans@nxp.com](mailto:christine.cloostermans@nxp.com)

## Authors' Addresses

**Michael Prorock**

Tradeverifyd

Email: [mprorock@mesur.io](mailto:mprorock@mesur.io)**Orie Steele**

Tradeverifyd

Email: [orie@or13.io](mailto:orie@or13.io)