

Classic McEliece:
conservative code-based cryptography
Round 2

<https://classic.mceliece.org/>

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Conservative code-based encryption

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We follow best practices to obtain an IND-CCA KEM.

For Round 2, we added more parameter sets, as requested.

One-wayness (OW-Passive)

Fundamental security question (SDP):

Given random parity-check matrix H and syndrome s ,
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- ▶ Write $H = (I_{n-k} | T)$, public key is $(n - k) \times k$ matrix T ,
 $n - k = t \log_2 q$. H constructed from binary Goppa code.
- ▶ Encapsulate using e of weight t .
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Classic McEliece only uses Niederreiter's "dual" framework, and some decoding speedups. This improves efficiency while clearly preserving security.

Parameter sets

n	t	public key	secret key	ciphertext
8,192	128	1,357,824 bytes	14,080 bytes	240 bytes
Both n and t powers of 2. Same as Round 1.				
6,960	119	1,047,319 bytes	13,908 bytes	226 bytes
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Max security with $\text{pkbytes} \leq 2^{20}$. Same as Round 1.				
6,688	128	1,044,992 bytes	13,892 bytes	240 bytes
Max security with $\text{pkbytes} \leq 2^{20}$ if n and t are multiples of 32.				
4,608	96	524,160 bytes	13,568 bytes	188 bytes
Max security with $\text{pkbytes} \leq 2^{19}$ if n and t are multiples of 32.				
3,488	64	261,120 bytes	6,452 bytes	128 bytes
Max security with $\text{pkbytes} \leq 2^{18}$ if n and t are multiples of 32.				

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We could save another 32 bytes of ciphertext by removing plaintext confirmation in the IND-CCA transform.
However, plaintext confirmation has security advantages.

Even including these 32 bytes,
Classic McEliece has the smallest ciphertexts in the competition.

High degree of flexibility in choice of parameters.
Could increase key size to obtain even smaller ciphertexts.

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We provided four implementations for each parameter set, all constant-time: `ref`, `vec`, `sse`, `avx`.

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Times improved: e.g. for `mceliece8192128` (Haswell cycles)

- ▶ 4,000,000,000 → 811,681,256 for keygen
- ▶ 300,000 → 194,500 for encaps
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For `mceliece8192128` (time-optimized)

- ▶ 1,286,179 for keygen
- ▶ 6,528 for encaps
- ▶ 26,237 for decaps

(cycles at 28.4MHz on Virtex-7 XC7V2000T FPGA).

Key-generation speed

Classic McEliece uses keys in systematic form.

We choose to abort if left $r \times r$ submatrix has not full rank.

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We introduced and analyzed (μ, ν) -semi-systematic form to

- ▶ achieve KeyGen success probability about $1 - 2^{\mu-\nu}$,
- ▶ obtain a fast constant-time implementation of Gaussian elimination with pivoting limited by (μ, ν) .

We have implemented 5 additional parameter sets with $(\mu, \nu) = (32, 64)$ as possible future proposals.

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Bernstein-Lange “McTiny” fits McEliece into tiny network servers, even with forward secrecy.

NIST submission Classic McEliece

- ▶ Security asymptotics unchanged by 40 years of cryptanalysis.
- ▶ Short ciphertexts.
- ▶ Efficient and straightforward conversion
OW-CPA PKE \rightarrow IND-CCA KEM.
- ▶ Open-source (public domain) implementations.
 - ▶ Constant-time software implementations.
 - ▶ FPGA implementation of full cryptosystem.
- ▶ No patents.

See <https://classic.mceliece.org> for more details.