
fastecdsa Documentation

Release 2.1.0

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Feb 20, 2020

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CHAPTER 1

Installation

The only actively supported operating systems at this time are most Linux distros and OS X.

You can use pip: `$ pip install fastecdsa` or clone the repo and use `$ python setup.py install`. Note that you need to have a C compiler (you can check this via e.g. `$ which gcc` or `$ which clang`). You also need to have [GMP](#) on your system as the underlying C code in this package includes the `gmp.h` header (and links against gmp via the `-lgmp` flag).

1.1 Installing Dependencies

1.1.1 Ubuntu / Debian

```
$ sudo apt-get install gcc python-dev libgmp3-dev
```

1.1.2 RHEL / CentOS

```
$ sudo yum install gcc python-devel gmp-devel
```


2.1 fastecdsa.curve

class fastecdsa.curve.**Curve** (*name: str, p: int, a: int, b: int, q: int, gx: int, gy: int, oid: bytes = None*)

Bases: object

Representation of an elliptic curve.

Defines a group for the arithmetic operations of point addition and scalar multiplication. Currently only curves defined via the equation $y^2 \equiv x^3 + ax + b \pmod{p}$ are supported.

Attributes:

- name (str): The name of the curve
- p (int): The value of p in the curve equation.
- a (int): The value of a in the curve equation.
- b (int): The value of b in the curve equation.
- q (int): The order of the base point of the curve.
- oid (bytes): The object identifier of the curve.

G

The base point of the curve.

For the purposes of ECDSA this point is multiplied by a private key to obtain the corresponding public key. Make a property to avoid cyclic dependency of Point on Curve (a point lies on a curve) and Curve on Point (curves have a base point).

__init__ (*name: str, p: int, a: int, b: int, q: int, gx: int, gy: int, oid: bytes = None*)
Initialize the parameters of an elliptic curve.

WARNING: Do not generate your own parameters unless you know what you are doing or you could generate a curve severely less secure than you think. Even then, consider using a standardized curve for the sake of interoperability.

Currently only curves defined via the equation $y^2 \equiv x^3 + ax + b \pmod{p}$ are supported.

Args:

name (string): The name of the curve
 p (int): The value of p in the curve equation.
 a (int): The value of a in the curve equation.
 b (int): The value of b in the curve equation.
 q (int): The order of the base point of the curve.
 gx (int): The x coordinate of the base point of the curve.
 gy (int): The y coordinate of the base point of the curve.
 oid (bytes): The object identifier of the curve.

__repr__ () → str
 Return repr(self).

__weakref__
 list of weak references to the object (if defined)

evaluate (x: int) → int
 Evaluate the elliptic curve polynomial at 'x'

Args: x (int): The position to evaluate the polynomial at

Returns: int: the value of $(x^3 + ax + b) \bmod p$

classmethod get_curve_by_oid (oid: bytes)
 Get a curve via it's object identifier.

is_point_on_curve (point: (<class 'int'>, <class 'int'>)) → bool
 Check if a point lies on this curve.

The check is done by evaluating the curve equation $y^2 \equiv x^3 + ax + b \pmod{p}$ at the given point (x, y) with this curve's domain parameters (a, b, p) . If the congruence holds, then the point lies on this curve.

Args: point (long, long): A tuple representing the point P as an (x, y) coordinate pair.

Returns: bool: True if the point lies on this curve, otherwise False.

2.2 fastecdsa.ecdsa

exception fastecdsa.ecdsa.EcdsaError (msg)
 Bases: Exception

fastecdsa.ecdsa.sign (msg: MsgTypes, d: int, curve: fastecdsa.curve.Curve = P256, hashfunc=<builtin function openssl_sha256>, prehashed: bool = False)
 Sign a message using the elliptic curve digital signature algorithm.

The elliptic curve signature algorithm is described in full in FIPS 186-4 Section 6. Please refer to <http://nvlpubs.nist.gov/nistpubs/FIPS/NIST.FIPS.186-4.pdf> for more information.

Args:

msg (str|bytes|bytearray): A message to be signed.
 d (int): The ECDSA private key of the signer.
 curve (fastecdsa.curve.Curve): The curve to be used to sign the message.
 hashfunc (_hashlib.HASH): The hash function used to compress the message.


```
fastecdsa.ecdsa.verify(sig: (<class 'int'>, <class 'int'>), msg: MsgTypes, Q: fastecdsa.point.Point,
                        curve: fastecdsa.curve.Curve = P256, hashfunc=<built-in function
                        openssl_sha256>) → bool
```

Verify a message signature using the elliptic curve digital signature algorithm.

The elliptic curve signature algorithm is described in full in FIPS 186-4 Section 6. Please refer to <http://nvlpubs.nist.gov/nistpubs/FIPS/NIST.FIPS.186-4.pdf> for more information.

Args:

sig (int, int): The signature for the message.

msg (str|bytes|bytearray): A message to be signed.

Q (fastecdsa.point.Point): The ECDSA public key of the signer.

curve (fastecdsa.curve.Curve): The curve to be used to sign the message.

hashfunc (_hashlib.HASH): The hash function used to compress the message.

Returns: bool: True if the signature is valid, False otherwise.

Raises:

fastecdsa.ecdsa.EcdsaError: If the signature or public key are invalid. Invalid signature in this case means that it has values less than 1 or greater than the curve order.

2.3 fastecdsa.encoding

```
class fastecdsa.encoding.KeyEncoder
```

Bases: object

Base class that any encoding class for EC keys should derive from.

All overriding methods should be static.

```
class fastecdsa.encoding.SigEncoder
```

Bases: object

Base class that any encoding class for EC signatures should derive from.

All overriding methods should be static.

2.4 fastecdsa.encoding.der

```
class fastecdsa.encoding.der.DEREncoder
```

Bases: *fastecdsa.encoding.SigEncoder*

```
static decode_signature(sig: bytes) -> (<class 'int'>, <class 'int'>)
```

Decode an EC signature from serialized DER format as described in <https://tools.ietf.org/html/rfc2459> (section 7.2.2) and as detailed by bip-0066

Returns (r,s)

```
static encode_signature(r: int, s: int) → bytes
```

Encode an EC signature in serialized DER format as described in <https://tools.ietf.org/html/rfc2459> (section 7.2.2) and as detailed by bip-0066

Args: r, s

Returns: bytes: The DER encoded signature

exception `fastecdsa.encoding.der.InvalidDerSignature`
 Bases: `Exception`

2.5 fastecdsa.encoding.pem

class `fastecdsa.encoding.pem.PEMEncoder`
 Bases: `fastecdsa.encoding.KeyEncoder`

static decode_private_key (*pemdata: str*) -> (`<class 'int'>`, `<class 'fastecdsa.point.Point'>`)
 Decode an EC key as described in [RFC 5915](#) and [RFC 5480](#).

Args: *pemdata* (bytes): A sequence of bytes representing an encoded EC key.

Returns: (long, `fastecdsa.point.Point`): A private key, public key tuple. If the encoded key was a public key the first entry in the tuple is None.

static decode_public_key (*pemdata: str, curve: fastecdsa.curve.Curve = None*) -> `fastecdsa.point.Point`
 Delegate to private key decoding but return only the public key

static encode_private_key (*d: int, Q: fastecdsa.point.Point = None, curve: fastecdsa.curve.Curve = None*) -> str
 Encode an EC keypair as described in [RFC 5915](#).

Args:

- d* (long): An ECDSA private key.
- Q* (`fastecdsa.point.Point`): The ECDSA public key.
- curve* (`fastecdsa.curve.Curve`): The curve that the private key is for.

Returns: str: The ASCII armored encoded EC keypair.

static encode_public_key (*Q: fastecdsa.point.Point*) -> str
 Encode an EC public key as described in [RFC 5480](#).

Returns: str: The ASCII armored encoded EC public key.

2.6 fastecdsa.encoding.sec1

exception `fastecdsa.encoding.sec1.InvalidSEC1PublicKey`
 Bases: `Exception`

class `fastecdsa.encoding.sec1.SEC1Encoder`
 Bases: `fastecdsa.encoding.KeyEncoder`

static decode_public_key (*key: bytes, curve: fastecdsa.curve.Curve*) -> `fastecdsa.point.Point`
 Decode a public key as described in <http://www.secg.org/SEC1-Ver-1.0.pdf> in sections 2.3.3/2.3.4
 compressed: 04 + x_bytes + y_bytes uncompressed: 02 or 03 + x_bytes

Args: *key* (bytes): public key encoded using the SEC1 format *curve* (`fastecdsa.curve.Curve`): Curve to use when decoding the public key

Returns: `Point`: The decoded public key

Raises: `InvalidSEC1PublicKey`

static encode_public_key (*point: fastecdsa.point.Point, compressed: bool = True*) -> bytes

Encode a public key as described in <http://www.secg.org/SEC1-Ver-1.0.pdf>

in sections 2.3.3/2.3.4 compressed: 04 + x_bytes + y_bytes uncompressed: 02 or 03 + x_bytes

Args: point (fastecdsa.point.Point): Public key to encode compressed (bool): Set to False if you want an uncompressed format

Returns: bytes: The SEC1 encoded public key

2.7 fastecdsa.keys

`fastecdsa.keys.export_key(key, curve: fastecdsa.curve.Curve = None, filepath: str = None, encoder=<class 'fastecdsa.encoding.pem.PEMEncoder'>)`

Export a public or private EC key in PEM format.

Args:

key (fastecdsa.point.Point | int): A public or private EC key

curve (fastecdsa.curve.Curve): The curve corresponding to the key (required if the key is a private key)

filepath (str): Where to save the exported key. If None the key is simply printed.

encoder (type): The class used to encode the key

`fastecdsa.keys.gen_keypair(curve: fastecdsa.curve.Curve) -> (<class 'int'>, <class 'fastecdsa.point.Point'>)`

Generate a keypair that consists of a private key and a public key.

The private key d is an integer generated via a cryptographically secure random number generator that lies in the range $[1, n)$, where n is the curve order. The public key Q is a point on the curve calculated as $Q = dG$, where G is the curve's base point.

Args: curve (fastecdsa.curve.Curve): The curve over which the keypair will be calculated.

Returns: int, fastecdsa.point.Point: Returns a tuple with the private key first and public key second.

`fastecdsa.keys.gen_private_key(curve: fastecdsa.curve.Curve, randfunc=<built-in function urandom>) -> int`

Generate a private key to sign data with.

The private key d is an integer generated via a cryptographically secure random number generator that lies in the range $[1, n)$, where n is the curve order. The default random number generator used is `/dev/urandom`.

Args:

curve (fastecdsa.curve.Curve): The curve over which the key will be calculated.

randfunc (function): A function taking one argument 'n' and returning a bytestring of n random bytes suitable for cryptographic use. The default is "os.urandom"

Returns: int: Returns a positive integer smaller than the curve order.

`fastecdsa.keys.get_public_key(d: int, curve: fastecdsa.curve.Curve) -> fastecdsa.point.Point`

Generate a public key from a private key.

The public key Q is a point on the curve calculated as $Q = dG$, where d is the private key and G is the curve's base point.

Args:

d (long): An integer representing the private key.

curve (fastecdsa.curve.Curve): The curve over which the key will be calculated.

Returns: fastecdsa.point.Point: The public key, a point on the given curve.

```
fastecdsa.keys.get_public_keys_from_sig(sig: (<class 'int'>, <class 'int'>), msg,
                                         curve: fastecdsa.curve.Curve = P256,
                                         hashfunc=<built-in function openssl_sha256>)
                                         -> (<class 'fastecdsa.point.Point'>, <class
                                              'fastecdsa.point.Point'>)
```

Recover the public keys that can verify a signature / message pair.

Args:

sig (int, int): A ECDSA signature.
 msg (str|bytes|bytearray): The message corresponding to the signature.
 curve (fastecdsa.curve.Curve): The curve used to sign the message.
 hashfunc (_hashlib.HASH): The hash function used to compress the message.

Returns:

(fastecdsa.point.Point, fastecdsa.point.Point): The public keys that can verify the signature for the message.

```
fastecdsa.keys.import_key(filepath: str, curve: fastecdsa.curve.Curve = None, public: bool = False,
                          decoder=<class 'fastecdsa.encoding.pem.PEMEncoder'>)
```

Import a public or private EC key in PEM format.

Args:

filepath (str): The location of the key file
 public (bool): Indicates if the key file is a public key
 decoder (fastecdsa.encoding.KeyEncoder): The class used to parse the key

Returns: (long, fastecdsa.point.Point): A (private key, public key) tuple. If a public key was imported then the first value will be None.

2.8 fastecdsa.point

exception fastecdsa.point.CurveMismatchError (curve1, curve2)

Bases: Exception

__init__ (curve1, curve2)

Initialize self. See help(type(self)) for accurate signature.

__weakref__

list of weak references to the object (if defined)

class fastecdsa.point.Point (x: int, y: int, curve=P256)

Bases: object

Representation of a point on an elliptic curve.

Attributes:

x (int): The x coordinate of the point.
 y (int): The y coordinate of the point.
 curve (Curve): The curve that the point lies on.

__add__ (other)

Add two points on the same elliptic curve.

Args:

self (Point): a point *P* on the curve

other (*Point*): a point Q on the curve

Returns: *Point*: A point R such that $R = P + Q$

`__eq__` (*other*) \rightarrow bool
Return self==value.

`__init__` (*x: int, y: int, curve=P256*)
Initialize a point on an elliptic curve.

The x and y parameters must satisfy the equation $y^2 \equiv x^3 + ax + b \pmod{p}$, where a , b , and p are attributes of the curve parameter.

Args:

x (int): The x coordinate of the point.
 y (int): The y coordinate of the point.
curve (*Curve*): The curve that the point lies on.

`__mul__` (*scalar: int*)
Multiply a *Point* on an elliptic curve by an integer.

Args:

self (*Point*): a point P on the curve
other (int): an integer $d \in \mathbb{Z}_q$ where q is the order of the curve that P is on

Returns: *Point*: A point R such that $R = P * d$

`__neg__` ()
Return the negation of a *Point* i.e. the points reflection over the x -axis.

Args:

self (*Point*): a point P on the curve

Returns: *Point*: A point $R = (P_x, -P_y)$

`__radd__` (*other*)
Add two points on the same elliptic curve.

Args:

self (*Point*): a point P on the curve
other (*Point*): a point Q on the curve

Returns: *Point*: A point R such that $R = R + Q$

`__repr__` () \rightarrow str
Return repr(self).

`__rmul__` (*scalar: int*)
Multiply a *Point* on an elliptic curve by an integer.

Args:

self (*Point*): a point P on the curve
other (long): an integer $d \in \mathbb{Z}_q$ where q is the order of the curve that P is on

Returns: *Point*: A point R such that $R = d * P$

`__str__` ()
Return str(self).

`__sub__` (*other*)
Subtract two points on the same elliptic curve.

Args:

self (*Point*): a point P on the curve
other (*Point*): a point Q on the curve

Returns: *Point*: A point R such that $R = P - Q$

__weakref__

list of weak references to the object (if defined)

2.9 fastecdsa.util

class fastecdsa.util.**RFC6979** (*msg, x, q, hashfunc*)

Bases: object

Generate a nonce per RFC6979.

In order to avoid reusing a nonce with the same key when signing two different messages (which leaks the private key) RFC6979 provides a deterministic method for generating nonces. This is based on using a pseudo-random function (HMAC) to derive a nonce from the message and private key. More info here: <http://tools.ietf.org/html/rfc6979>.

Attributes:

msg (string): A message being signed.
x (int): An ECDSA private key.
q (int): The order of the generator point of the curve being used to sign the message.
hashfunc (_hashlib.HASH): The hash function used to compress the message.

gen_nonce ()

<http://tools.ietf.org/html/rfc6979#section-3.2>

fastecdsa.util.**mod_sqrt** (*a: int, p: int*) -> (<class 'int'>, <class 'int'>)

Compute the square root of $a \pmod p$

In other words, find a value x such that $x^2 \equiv a \pmod p$.

Args:

a (int): The value whose root to take.
p (int): The prime whose field to perform the square root in.

Returns: (int, int): the two values of x satisfying $x^2 \equiv a \pmod p$.

fastecdsa.util.**msg_bytes** (*msg*) → bytes

Return bytes in a consistent way for a given message.

The message is expected to be either a string, bytes, or an array of bytes.

Args:

msg (str|bytes|bytearray): The data to transform.

Returns: bytes: The byte encoded data.

Raises: ValueError: If the data cannot be encoded as bytes.

fastecdsa.util.**validate_type** (*instance: object, expected_type: type*)

Validate that instance is an instance of the expected_type.

Args:

instance: The object whose type is being checked

expected_type: The expected type of instance

var_name: The name of the object

Raises: TypeError: If instance is not of type expected_type

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