ID	DESCRIPTION	SEVERITY	STATUS
SF-6	The Compound Factor Can Cause Overflows in Scenarios with High Interest Rates over Long Periods	Low	Fixed
SF-7	Haircuts in Deployed Contract Have Zero Values for All Currencies	Low	Acknowledged
SF-8	Missing Input Validation	Low	Fixed
SF-9	Privileged Roles and Ownership	Low	Acknowledged
SF-10	`ZCTokens` May Use More Decimals than Is Supported by Third-Party Applications	Informational	Fixed
SF-11	Semantical Mismatch Between Function's Name and Behavior	Informational	Fixed
SF-12	Borrowing Users Increase Their Liquidation Risk when Minting `ZCTokens`	Informational	Acknowledged
SF-13	Some Erc20 Tokens Do Not Support Transfers with Permission Signatures	Informational	Acknowledged
SF-14	Dead Code	Informational	Fixed

Assessment Breakdown

Quantstamp's objective was to evaluate the repository for security-related issues, code quality, and adherence to specification and best practices.

> **Disclaimer**
> Only features that are contained within the repositories at the commit hashes specified on the front page of the report are within the scope of the audit and fix review. All features added in future revisions of the code are excluded from consideration in this report.

Possible issues we looked for included (but are not limited to):

- Transaction-ordering dependence
- Timestamp dependence
- Mishandled exceptions and call stack limits
- Unsafe external calls
- Integer overflow / underflow
- Number rounding errors
- Reentrancy and cross-function vulnerabilities
- Denial of service / logical oversights
- Access control
- Centralization of power
- Business logic contradicting the specification
- Code clones, functionality duplication
- Gas usage
- Arbitrary token minting

Methodology

1. Code review that includes the following
    1. Review of the specifications, sources, and instructions provided to Quantstamp to make sure we understand the size, scope, and functionality of the smart contract.
    2. Manual review of code, which is the process of reading source code line-by-line in an attempt to identify potential vulnerabilities.
    3. Comparison to specification, which is the process of checking whether the code does what the specifications, sources, and instructions provided to Quantstamp describe.
2. Testing and automated analysis that includes the following:
    1. Test coverage analysis, which is the process of determining whether the test cases are actually covering the code and how much code is exercised when we run those test cases.
    2. Symbolic execution, which is analyzing a program to determine what inputs cause each part of a program to execute.
3. Best practices review, which is a review of the smart contracts to improve efficiency, effectiveness, clarity, maintainability, security, and control based on the established industry and academic practices, recommendations, and research.
4. Specific, itemized, and actionable recommendations to help you take steps to secure your smart contracts.

Scope

Files Included

Repo: `https://github.com/Secured-Finance/contracts(f1c62764ccf9782b2ff2de5088abc439566b7a0b)` Files: `contracts/protocol/*`

Findings

SF-1

Partial Withdrawal Requests of `ZCTokens` Results in Withdrawing More than What Is Requested

Medium | Fixed

> **Update**
> Marked as "Fixed" by the client. Addressed in: `3e8bda875a75cd8991ede8d0c35dff322166aad5` .

File(s) affected: `LendingMarketUserLogic.sol`

Description: Users have the capability to withdraw a specified `_amount` of ZC tokens using the `_withdrawZCToken()` and `_withdrawZCPerpetualToken()` functions. However, the presence of the `isAll` flag, as determined by the `_getWithdrawableZCTokenAmount()` function, indicates that users can withdraw their entire position for a specific maturity. This functionality effectively eliminates the option for partial withdrawals. Specifically, based on the `isAll` value, either `0` or the `_amount` specified will be forwarded to the `lock()` function. The `lock()` function interprets an amount of `0` as an instruction to lock the user's total balance or the specified amount. Consequently, if `isAll` is set to `true` for a user intending to withdraw only `8` out of `10` tokens, all `10` tokens will be locked, not just the `8` requested. This could inadvertently impact the user's risk management strategies, as it differs from their initial withdrawal intent.

Note: This issue was raised by the client during the audit process.

Recommendation: Consider updating the code to support partial withdrawals of ZC Tokens.

SF-2

Non-Perpetual `ZCTokens` Are Deployed with an Incorrect Amount of Decimals

Medium | Fixed

> **Update**
> Marked as "Fixed" by the client. Addressed in: `f533c161fa2ad8e1e120ae77ff4d8b8406e2087e` . The client provided the following explanation:
>
> > "To keep our protocol for a long time even with extremely high interest rates, we need to set additional decimals for ZC Tokens but some protocol and third-party tools can't support 36 as token decimals. So we use 6 as additional decimals instead of 18."

> **Update**
> We highly recommend conducting comprehensive testing on all edge cases, including conversions between FV and GV, as well as the minting and burning processes for both perpetual and non-perpetual ZC tokens. It is crucial to examine scenarios involving extreme decimal values (ranging from 0 to 44) and amounts (spanning from 1 wei to 50% of the total supply). Additionally, it's important to verify that the system accurately manages any loss of precision.

File(s) affected: `LendingMarketUserLogic.sol`

Description: The function `LendingMarketOperationLogic.createZCToken()` is used to deploy two types of ZC Tokens: perpetual and non-perpetual.

- Non-perpetual ZC Tokens for an underlying token `T` should have a number of decimals that match the amount of decimal of `T` .
- Perpetual ZC Tokens for this same underlying token `T` should have a number of decimals that matches the number of decimals of the genesis value of `T` , which should have 18 additional decimals.

However, all ZCTokens are deployed with 18 additional decimals to match the genesis value amount. As a result, users withdrawing non-perpetual ZC Tokens may think that they received 1e18 times less than expected.

Note: This issue was raised by the client during the audit process.

Recommendation: Consider setting the number of decimals based on the maturity (0 for perpetual, non-zero for non-perpetuals).

SF-3
Deposits with Permits Can Be Delayed by Front-Running the Approval

• Low Acknowledged

> **Update**
> Marked as "Acknowledged" by the client. The client provided the following explanation:
>
> This is a general behavior of ERC2612. We can accept this.

Description: When a user calls a function that uses permit signatures to approve the tokens for deposit, the signature parameters can be pulled from the the mempool and used to approve the token directly. Since the permit signature uses nonce protection, the original function call would fail if someone else used the signature first. This affects all functions that use `permit()` to approve tokens before transferring them.

Exploit Scenario:

1. Alice wants to perform the operation `OP1`: `TokenVault.depositWithPermitTo()` in order to deposit 3 BTC for BOB. The permit signature `PS` is a permission of 3 BTC from Alice to the TokenVault contract.
2. Attacker, Cameron, takes `PS` and consumes it on the BTC contract `permit()` function to front-run Alice's call, so `OP1` will fail because the nonce of this signature is now used in the BTC contract.
3. While funds are not at risk, it could be a way for Cameron to delay BOB from getting an emergency refill of his position that would prevent a liquidation.

Recommendation: Consider documenting that Alice can be front-run when calling functions that involve a permit signature. Users can avoid this by using a private relay to submit transactions. In addition, consider adding a `try-catch` block to revert with a custom error if the call to `permit()` reverts.

SF-4 Incorrect Value Used when Emitting `LiquidatorFeeRateUpdated` Events

• Low Fixed

> **Update**
> Marked as "Fixed" by the client. Addressed in: `a50c4b39147d482bf3e44b38281655958d531715`.

File(s) affected: `MixinLiquidationConfiguration.sol`

Description: The event `LiquidatorFeeRateUpdated` is defined as follows:

```
event LiquidatorFeeRateUpdated(uint256 previousRate, uint256 ratio);
```

However, when the value of `Storage.slot().liquidatorFeeRate` is updated in the function `_updateLiquidationConfiguration()`, the event will use for both fields the new value, instead of using the old and the new value:

```
if (_liquidatorFeeRate != Storage.slot().liquidatorFeeRate) {
    Storage.slot().liquidatorFeeRate = _liquidatorFeeRate;
    emit LiquidatorFeeRateUpdated(Storage.slot().liquidatorFeeRate, _liquidatorFeeRate);
}
```

This can negatively impact external observers of the protocol.

Recommendation: Consider inverting the lines used to update the value and to emit the events.

SF-5 `OrderBookId` Can Overflow

• Low Fixed

> **Update**
> Marked as "Fixed" by the client. Addressed in: `ab9197c1a9f38956b049145b3ee42c9e163af117`.

File(s) affected: `OrderBookLogic.sol`

Description: Order book IDs are stored in `uint8` variables that hold a maximum value of 255. Each time a new order book is created, the previous ID will be incremented by 1. Given the expected rate of a new order book every 3 months, it will take approximately 63 years before new order books cannot be created due to overflow, effectively freezing the protocol.

Note: This issue was raised by the client during the audit process.

Recommendation: Consider reusing previous `orderBookId` values from 1 after 255 has been reached.

SF-6
The Compound Factor Can Cause Overflows in Scenarios with High Interest Rates over Long Periods

Low Fixed

> **Update**
> Marked as "Fixed" by the client. Addressed in: `dd25a0a57de312a0e67de447f86e52519fcb07d2`.

File(s) affected: `GenesisValueVault.sol`

Description: In rare cases, the compound factor can become very large and cause an overflow when converting from genesis value to future value. This only happens in circumstances of high interest rates for extended periods such as 200% APR for 197 years.

Note: This issue was raised by the client during the audit process.

Recommendation: Consider using a math library to avoid overflows.

SF-7
Haircuts in Deployed Contract Have Zero Values for All Currencies

Low Acknowledged

> **Update**
> Marked as "Acknowledged" by the client. The client provided the following explanation:
>
> > This is what we intended. To reduce liquidation risk at the beginning, we had set 0 for all haircuts to avoid users using ZC Bonds as collateral between different currencies.

File(s) affected: `FundManagementLogic.sol`, `LendingMarketUserLogic.sol`

Description: The functions `LendingMarketUserLogic._getWithdrawableAmount()` and `FundManagementLogic.calculateFunds()` apply haircuts to values, which are stored in the `CurrencyController` contract. However, all the currencies in the deployed contract at `0x7dca6b6BF30cd28ADe83e86e21e82e3F852bF2DC` (address taken from the docs) have zero values as their haircuts. This may lead to unwanted consequences when risk management is required while valuing user assets.

Recommendation: Add haircuts for all currencies to avoid volatility in currency prices and potential risks for the platform.

SF-8 Missing Input Validation

Low Fixed

> **Update**
> Marked as "Mitigated" by the client. Addressed in: `7ccb862ca858e70667ed157acdbb26691c883fff`. The client provided the following explanation:
>
> > In our protocol, any heartbeats can be acceptable.
>
> Item 1 is fixed. Item 2 is working as expected.

File(s) affected: `MixinLiquidationConfiguration.sol`

Description: It is important to validate inputs, even if they only come from trusted addresses, to avoid human error:

In `MixinLiquidationConfiguration.sol`:

1. In the function `_updateLiquidationConfiguration()`, there is no check making sure that `fullLiquidationThresholdRate < liquidationThresholdRate`.

In `CurrencyController.sol`:

1. In the function `_updatePriceFeed()`, there is no minimum and maximum check for the value of the heartbeats.

Recommendation: We recommend adding the relevant checks.

SF-9 Privileged Roles and Ownership

Low Acknowledged

> **Update**
> Marked as "Acknowledged" by the client. The client provided the following explanation:

Understood. We will remove this function to be used for only migration.

File(s) affected: `LendingMarketController.sol`

Description: In addition to the roles described in the previous audit report, the owner can create new ZCTokens.

Recommendation: Consider making users aware of the privileged roles via documentation.

SF-10
`ZCTokens` May Use More Decimals than Is Supported by Third-Party Applications

Informational | Fixed

Update
Marked as "Fixed" by the client. Addressed in: `f533c161fa2ad8e1e120ae77ff4d8b8406e2087e`. The client provided the following explanation:

> Fixed together with SF-2.

Description: Some `ZCTokens` are expected to have as many as 36 decimals. While this does not create any issues within Secured Finance, third-party applications, such as wallets, can have issues supporting tokens with too many decimals.

Note: This issue was raised by the client during the audit process.

Recommendation: Consider reducing the number of decimals used for `ZCTokens`.

SF-11
Semantical Mismatch Between Function's Name and Behavior

Informational | Fixed

Update
Marked as "Fixed" by the client. Addressed in: `466aec13fe018c088f1af5d971dd9ca5619e084b`.

File(s) affected: `LendingMarketController.sol`

Description: In the contract `LendingMarketController`, the modifier `ifValidMaturity()` contains the following line of code:

```
if (isValidMaturity(_ccy, _maturity)) revert InvalidMaturity();
```

This line is a contradiction but still works because the function `isValidMaturity()` returns `true` if the maturity does not exist, and false if the maturity does exist. As a result, this adds confusion for external readers of the code.

Recommendation: Consider removing the confusion from this portion of the code by aligning the name and the behavior of the function `isValidMaturity()`.

SF-12
Borrowing Users Increase Their Liquidation Risk when Minting `ZCTokens`

Informational | Acknowledged

Update
Marked as "Acknowledged" by the client. The client provided the following explanation:

> We will notify this risk on our UI.

File(s) affected: `LendingMarketUserLogic.sol`

Description: Users can become close to being liquidated if they have ZC bonds that are used as collateral and convert their maximum balance of the withdrawable amount. In this extreme case, a liquidation can happen in the next block if a slight update of the price happens.

Recommendation: Consider documenting this risk to end-users, and adding to the front end an option for users to use a security threshold between 0 and 100% to manually manage their risk of liquidation.

SF-13
Some Erc20 Tokens Do Not Support Transfers with Permission Signatures

• Informational Acknowledged

> **Update**
> Marked as "Acknowledged" by the client. The client provided the following explanation:
>
> Understood. We will remove this function to be used for only migration.

File(s) affected: `TokenVault.sol`

Description: The new version of the codebase brings two additional functions letting users deposit tokens to the contract using permission signatures (ERC2612). However, not all tokens support this feature. Worse, few ERC20 tokens such as WETH can offer a `fallback()` function that will lead to any attempt to execute the function `permit()` on this contract to silently fail (concept of phantom functions). Even if right now, no concrete impact was found since only `msg.sender` can originate a signature that will transfer tokens from its address, silent failures should be avoided.

Recommendation: Consider adding a whitelist of token addresses that support transfers with a permission signature, and only allow these tokens to be transferred by the functions `depositWithPermitTo()` and `depositWithPermitFrom()`.

SF-14 Dead Code

• Informational Fixed

> **Update**
> Marked as "Fixed" by the client. Addressed in: `6df5354569c105bb87c106e5a7e88ab9eaae8e0a`.

Description: "Dead" code refers to code that is never executed and hence makes no impact on the final result of running a program. Dead code raises a concern, since either the code is unnecessary or the necessary code's results were ignored.

`_calculatePVFromFV()` is an overloaded function. One version takes two `uint256` as input and the other takes one `uint256` and one `int256`. The version that takes two `uint256` is not called.

Recommendation: Remove or refactor the abovementioned code statements.

Definitions

- **High severity** – High-severity issues usually put a large number of users' sensitive information at risk, or are reasonably likely to lead to catastrophic impact for client's reputation or serious financial implications for client and users.
- **Medium severity** – Medium-severity issues tend to put a subset of users' sensitive information at risk, would be detrimental for the client's reputation if exploited, or are reasonably likely to lead to moderate financial impact.
- **Low severity** – The risk is relatively small and could not be exploited on a recurring basis, or is a risk that the client has indicated is low impact in view of the client's business circumstances.
- **Informational** – The issue does not post an immediate risk, but is relevant to security best practices or Defence in Depth.
- **Undetermined** – The impact of the issue is uncertain.
- **Fixed** – Adjusted program implementation, requirements or constraints to eliminate the risk.
- **Mitigated** – Implemented actions to minimize the impact or likelihood of the risk.
- **Acknowledged** – The issue remains in the code but is a result of an intentional business or design decision. As such, it is supposed to be addressed outside the programmatic means, such as: 1) comments, documentation, README, FAQ; 2) business processes; 3) analyses showing that the issue shall have no negative consequences in practice (e.g., gas analysis, deployment settings).

Toolset

The notes below outline the setup and steps performed in the process of this audit.

Setup

Tool Setup:
- Slither v0.10.1

Steps taken to run the tools:

1. Install the Slither tool: `pip3 install slither-analyzer`
2. Run Slither from the project directory: `npm run security:slither`

Automated Analysis

Slither

Slither was used to get a static analysis of the repository. All the issues and recommendations are discussed in this report or classified as false positives.

Test Suite Results

The test suite has 1424 passing tests and 600 failing tests. The failing tests are a part of the auto-roll tests which iterate 800 times. The first 200 tests pass and then it fails on the 201st time. All subsequent calls fail. The test suite should be updated to ensure all tests are passing.

Fix Review: The test suite has been improved and now has 2044 passing tests.

```
> @secured-finance/contracts@1.1.0-beta.2 test
> DOTENV_CONFIG_PATH=.env.test hardhat test

Compiled 34 Solidity files successfully

  Integration Test: Auto-rolls
    Execute auto-roll with orders on the single market
      ✓ Fill an order
      ✓ Execute auto-roll (1st time)
      ✓ Execute auto-roll (2nd time)
    Execute auto-roll with orders on the multiple markets
      ✓ Fill an order on the closest maturity market
      ✓ Fill an order on the second closest maturity market
      ✓ Check total PVs
      ✓ Execute auto-roll
      ✓ Clean orders
    Execute auto-rolls with users who has open orders and filled orders.
      ✓ Fill an order
      ✓ Execute auto-roll
    Execute auto-rolls more times than the number of markets using the past auto-roll price
      ✓ Fill an order
      ✓ Execute auto-roll (1st time)
      ✓ Execute auto-roll (2nd time)
      ✓ Execute auto-roll (3rd time)
      ✓ Execute auto-roll (4th time)
      ✓ Execute auto-roll (5th time)
      ✓ Execute auto-roll (6th time)
      ✓ Execute auto-roll (7th time)
      ✓ Execute auto-roll (8th time)
      ✓ Execute auto-roll (9th time)
      ✓ Execute auto-roll (10th time)
    Execute auto-roll with many orders, Check the FV and GV
      ✓ Fill an order
      ✓ Check future values
      ✓ Execute auto-roll, Check genesis values
    Execute auto-roll well past maturity
      ✓ Fill an order
      ✓ Advance time
      ✓ Fail to create an order due to market closure
      ✓ Execute auto-roll

  Integration Test: Calculations
    Order Estimations
      Estimate a borrowing order result to be filled
        ✓ Deposit ETH
        ✓ Place a lending order on the ETH market
        ✓ Estimate a borrowing order result
      Estimate a lending order result to be filled
        ✓ Place a borrowing order on the ETH market
        ✓ Deposit ETH
        ✓ Estimate a lending order result
```

```
    Estimate a borrowing order result to be placed
      ✓ Deposit ETH
      ✓ Estimate a borrowing order result
    Estimate a borrowing order result to be placed with unit price less than min debt unit prices
      ✓ Deposit ETH
      ✓ Estimate a borrowing order result
    Estimate a lending order result to be placed
      ✓ Deposit ETH
      ✓ Estimate a lending order result
  Borrowable Amount Calculations
    Calculate the borrowable amount with deposit
      ✓ Deposit ETH
      ✓ Calculate the borrowable amount in ETH
      ✓ Calculate the borrowable amount in WFIL
    Calculate the borrowable amount with borrowing position (Haircut: 0)
      ✓ Deposit ETH
      ✓ Fill an order to get a borrowing position
      ✓ Calculate the borrowable amount in ETH(1)
      ✓ Calculate the borrowable amount in WFIL(1)
      ✓ Fill an order to partially use the borrowing position
      ✓ Calculate the borrowable amount in ETH(2)
      ✓ Calculate the borrowable amount in WFIL(2)
      ✓ Fill an order to use the whole borrowing position
      ✓ Calculate the borrowable amount in ETH(3)
      ✓ Calculate the borrowable amount in WFIL(3)
    Calculate the borrowable amount with borrowing position (Haircut: 5000)
      ✓ Deposit ETH
      ✓ Fill an order to get a borrowing position
      ✓ Calculate the borrowable amount in ETH(1)
      ✓ Calculate the borrowable amount in WFIL(1)
      ✓ Fill an order to partially use the borrowing position
      ✓ Calculate the borrowable amount in ETH(2)
      ✓ Calculate the borrowable amount in WFIL(2)
      ✓ Fill an order to use the whole borrowing position
      ✓ Calculate the borrowable amount in ETH(3)
      ✓ Calculate the borrowable amount in WFIL(3)
    Calculate the borrowable amount with borrowing position (Haircut: 9600)
      ✓ Deposit ETH
      ✓ Fill an order to get a borrowing position
      ✓ Calculate the borrowable amount in ETH(1)
      ✓ Calculate the borrowable amount in WFIL(1)
      ✓ Fill an order to partially use the borrowing position
      ✓ Calculate the borrowable amount in ETH(2)
      ✓ Calculate the borrowable amount in WFIL(2)
      ✓ Fill an order to use the whole borrowing position
      ✓ Calculate the borrowable amount in ETH(3)
      ✓ Calculate the borrowable amount in WFIL(3)
    Calculate the borrowable amount with deposit & borrowing position
      ✓ Deposit ETH
      ✓ Fill an order to get a borrowing position
      ✓ Calculate the borrowable amount in ETH
      ✓ Calculate the borrowable amount in WFIL

Integration Test: Deposit
  Deposit ETH, Withdraw all collateral
    ✓ Deposit ETH
    ✓ Withdraw all collateral
    ✓ Clean up funds
  Deposit WBTC, Withdraw all collateral
    ✓ Deposit WBTC
    ✓ Withdraw all collateral
    ✓ Clean up funds
  Deposit ETH twice, Withdraw all collateral
    ✓ Deposit ETH
    ✓ Withdraw partially
    ✓ Withdraw with over amount input
    ✓ Clean up funds
  Deposit multiple currency, Withdraw all collateral
    ✓ Deposit ETH (Non-ERC20 collateral currency)
    ✓ Deposit FIL (ERC20 non-collateral currency)
    ✓ Withdraw ETH with over amount input
    ✓ Clean up funds
```

```
    ✓ Deposit USDC (ERC20 collateral currency)
    ✓ Deposit WBTC (ERC20 collateral currency)
    ✓ Withdraw FIL (ERC20 non-collateral currency) with over amount input
    ✓ Clean up funds
  Deposit by multiple users
    ✓ Deposit FIL
    ✓ Withdraw by one user
    ✓ Withdraw from empty deposit
  Deposit by another user
    ✓ Deposit FIL
    ✓ Withdraw by caller
    ✓ Withdraw by the deposited user
  Deposit without prior approval
    ✓ Deposit USDC without prior approval
    ✓ Withdraw by one user
  Deposit new currency as collateral
    ✓ Register new currency as collateral
    ✓ Deposit TestToken
    ✓ Place an order
  Fill an borrowing order, Withdraw collateral
    ✓ Fill an order(WBTC)
    ✓ Fill an order(WFIL)
    ✓ Withdraw by borrower
    ✓ Withdraw by lender(empty deposit)
  Fill an lending order, Withdraw collateral
    ✓ Fill an order
    ✓ Withdraw by borrower
    ✓ Withdraw by lender(empty deposit)
  Fill orders on multiple markets, Withdraw collateral
    ✓ Fill an order on the FIL market
    ✓ Fill an order on the ETH market
    ✓ Withdraw by Alice
  Place orders, Withdraw collateral
    ✓ Deposit ETH
    ✓ Place orders
    ✓ Check withdrawable amount
    ✓ Withdraw ETH
  Withdraw non-collateral currencies while a active lending order exists
    ✓ Place lending orders for non-collateral currencies, WFIL and WBTC
    ✓ Withdraw all WFIL and WBTC deposit of bob and get deposit amount again
  Deposit and withdraw wFIL using MixinWallet
    ✓ Deposit wFIL on ReserveFund contract
    ✓ Withdraw all wFIL deposit on ReserveFund contract
    ✓ Deposit wFIL on ReserveFund contract using wallet transactions
    ✓ Withdraw all wFIL deposit on ReserveFund contract using wallet transaction
    ✓ Deposit wFIL on Liquidator contract
    ✓ Withdraw all wFIL deposit on Liquidator contract
    ✓ Deposit wFIL on Liquidator contract using wallet transactions
    ✓ Withdraw all wFIL deposit on liquidator contract using wallet transaction
  Fill an orders under min debt unit price, Withdraw collateral
    ✓ Fill an order with amount with over the min debt unit price
    ✓ Fill an order with amount with under the min debt unit price
    ✓ Check the withdrawable collateral amount of borrower
    ✓ Withdraw by borrower

Integration Test: Emergency terminations
  Execute emergency termination & redemption
    Including only healthy users
      ✓ Fill an order on the ETH market with depositing ETH
      ✓ Fill an order on the FIL market with depositing USDC
      ✓ Execute emergency termination
      ✓ Execute forced redemption
      ✓ Withdraw all collateral
    Including an auto-rolled position
      ✓ Fill an order on the ETH market with depositing ETH
      ✓ Execute auto-roll
      ✓ Execute emergency termination
      ✓ Execute forced redemption
    Including a liquidation user
      ✓ Fill an order on the ETH market with depositing ETH
      ✓ Fill an order on the FIL market with depositing USDC
      ✓ Update a price feed to change the wFIL price
```

```
        ✓ Execute emergency termination
        ✓ Execute forced redemption
      Including an insolvent user
        ✓ Fill an order on the ETH market with depositing ETH
        ✓ Fill an order on the FIL market with depositing USDC
        ✓ Fill an order for a huge amount to store fees in the reserve funds
        ✓ Update a price feed to change the wFIL price
        ✓ Execute emergency termination
        ✓ Execute forced redemption
        ✓ Withdraw all collateral

  Integration Test: Itayose (ERC20)
    Execute Itayose including pre-orders without prior approval
      ✓ Fill an order
      ✓ Crate pre-orders without prior approval
      ✓ Execute auto-roll
      ✓ Check the expected result before Itayose execution
      ✓ Execute Itayose with pre-order

  Integration Test: Itayose
    Execute Itayose on the single market without pre-order
      ✓ Fill an order
      ✓ Execute auto-roll
      ✓ Check the expected result before Itayose execution
      ✓ Execute Itayose without pre-order
    Execute Itayose with pre-order
      ✓ Fill an order
      ✓ Crate pre-orders
      ✓ Execute auto-roll
      ✓ Check the expected result before Itayose execution
      ✓ Execute Itayose with pre-order
    Execute Itayose with pre-order and execute clearing order process
      ✓ Crate pre-orders
      ✓ Check if clearing order process takes the opening price into accounts
    Execute Itayose with pre-order in same amount and execute clearing order process
      ✓ Crate pre-orders
      ✓ Check if clearing order process takes the opening price into accounts

  Integration Test: Liquidations
    Liquidations on FIL(non-collateral currency) market by ETH
      Increase FIL exchange rate, Execute liquidation once, Manage reserve funds
        ✓ Create orders
        ✓ Withdraw
┌─────────┬──────────┬─────────────────┬──────────────────────────┬─────────────────┬──────────────────────────┬──────────────────┐
│ (index) │ Coverage │ Maturity(WFIL) │         PV(WFIL)         │ Deposit(WFIL) │     Deposit(ETH)      │ Deposit(USDC) │
├─────────┼──────────┼─────────────────┼──────────────────────────┼─────────────────┼──────────────────────────┼──────────────────┤
│ Before  │  '8368'  │   1948147200   │ '-20000000000000000000' │      '0'      │ '1000000000000000000' │       '0'       │
│  After  │  '7575'  │   1948147200   │ '-99999999999999999999' │      '0'      │ '552307134710000000'  │       '0'       │
└─────────┴──────────┴─────────────────┴──────────────────────────┴─────────────────┴──────────────────────────┴──────────────────┘
        ✓ Execute liquidation
      Increase FIL exchange rate, Execute full liquidation
        ✓ Create orders
        ✓ Withdraw
┌─────────┬──────────┬─────────────────┬──────────────────────────┬─────────────────┬──────────────────────────┬──────────────────┐
│ (index) │ Coverage │ Maturity(WFIL) │         PV(WFIL)         │ Deposit(WFIL) │     Deposit(ETH)      │ Deposit(USDC) │
├─────────┼──────────┼─────────────────┼──────────────────────────┼─────────────────┼──────────────────────────┼──────────────────┤
│ Before  │  '8748'  │   1956009600   │ '-20000000000000000000' │      '0'      │ '1000000000000000000' │       '0'       │
│  After  │   '0'    │   1956009600   │           '0'           │      '0'      │  '63914918030000000'  │       '0'       │
└─────────┴──────────┴─────────────────┴──────────────────────────┴─────────────────┴──────────────────────────┴──────────────────┘
        ✓ Execute full liquidation
```

Execute auto-roll a borrowing position, Execute liquidation after auto-roll
✓ Create orders
✓ Withdraw
✓ Execute auto-roll

(index)	Coverage	Maturity(WFIL)	PV(WFIL)	Deposit(WFIL)	Deposit(ETH)	Deposit(USDC)
Before	'8340'	1971734400	'-219273561643835616511'	'0'	'1000000000000000000'	'0'
After	'7530'	1971734400	'-109636780822474227243'	'0'	'553785413208300000'	'0'

✓ Execute liquidation
Liquidate partially due to insufficient collateral
✓ Create orders
✓ Withdraw

(index)	Coverage	Maturity(WFIL)	PV(WFIL)	Deposit(WFIL)	Deposit(ETH)	Deposit(USDC)
Before	'22822'	1979596800	'-200000000000000000000'	'0'	'1000000000000000000'	'0'
After	'11579208923731619542357098500868790785326998466564056403945758400791312963993 5'	1979596800	'-106545413228416482157'	'0'	'0'	'0'

✓ Execute liquidation
✓ Withdraw funds on Liquidator contract
Liquidate partially due to insufficient collateral without the reserve fund after auto-roll
✓ Create orders
✓ Withdraw
✓ Execute auto-roll

(index)	Coverage	Maturity(WFIL)	PV(WFIL)	Deposit(WFIL)	Deposit(ETH)	Deposit(USDC)
Before	'23825'	1995321600	'-208793607305936073092'	'0'	'1000000000000000000'	'0'
After	'11579208923731619542357098500868790785326998466564056403945758400791312963993 5'	1995321600	'-125332193774416969805'	'0'	'0'	'0'

✓ Execute liquidation
Liquidate a borrowing position using the user's deposits and lending positions
✓ Create orders on the USDC market
✓ Create orders on the FIL market
✓ Withdraw

(index)	Coverage	Maturity(WFIL)	Maturity(USDC)	PV(WFIL)	PV(USDC)	Deposit(WFIL)	Deposit(ETH)	Deposit(USDC)
User(Before)	'9398'	2003184000	2003184000	'-131451726312142587685'	'997435247'	'0'	'0'	'0'
User(After)	'0'	2003184000	2003184000	'-63991017606'	'194992855'	'0'	'0'	'0'

(index)	Coverage	Maturity(WFIL)	Maturity(USDC)	PV(WFIL)	PV(USDC)	Deposit(WFIL)	Deposit(ETH)	Deposit(USDC)

Liquidator	'0'	2003184000	2003184000	'0'	'0'	'5900780207330660039'	'0'	'0'

- ✓ Execute liquidation

Liquidate a borrowing position using the user's lending positions after two auto-rolls

- ✓ Create orders on the USDC market
- ✓ Create orders on the FIL market
- ✓ Execute auto-roll twice
- ✓ Withdraw
- ✓ Create orders for unwinding

(index)	Coverage	Maturity(WFIL)	Maturity(USDC)	PV(WFIL)	PV(USDC)	Deposit(WFIL)	Deposit(ETH)	Deposit(USDC)
User(Before)	'8837'	2027376000	2027376000	'-137256610536639076132'	'1033718385'	'0'	'0'	'0'
User(After)	'0'	2027376000	2027376000	'0'	'251698822'	'0'	'0'	'0'

(index)	Coverage	Maturity(WFIL)	Maturity(USDC)	PV(WFIL)	PV(USDC)	Deposit(WFIL)	Deposit(ETH)	Deposit(USDC)
Liquidator(Before)	'0'	2027376000	2027376000	'0'	'0'	'0'	'0'	'999928215'
Liquidator(After)	'4528'	2027376000	2027376000	'-137256610536639076132'	'767402374'	'0'	'0'	'999928215'

- ✓ Execute liquidation

Liquidate a borrowing position using the user's multiple lending positions

- ✓ Create orders on the multiple USDC markets
- ✓ Create orders on the FIL market
- ✓ Withdraw

(index)	Coverage	Maturity(WFIL)	Maturity(USDC-1)	Maturity(USDC-2)	PV(WFIL)	PV(USDC-1)	PV(USDC-2)	Deposit(WFIL)	Deposit(ETH)	Deposit(USDC)
User(Before)	'9414'	2035238400	2035238400	2043100800	'-131451726312142587685'	'332478416'	'663294852'	'0'	'0'	'0'
User(After)	'0'	2035238400	2035238400	2043100800	'-63991017606'	'0'	'193330876'	'0'	'0'	'0'

(index)	Coverage	Maturity(WFIL)	Maturity(USDC-1)	Maturity(USDC-2)	PV(WFIL)	PV(USDC-1)	PV(USDC-2)	Deposit(WFIL)	Deposit(ETH)	Deposit(USDC)
Liquidator	'0'	2035238400	2035238400	2043100800	'0'	'0'	'0'	'5703437537353127956'	'0'	'0'

- ✓ Execute liquidation

Liquidates a borrowing position of users with open orders in the currency used for collateral

- ✓ Create a lending order on the USDC market
- ✓ Create orders on the FIL market
- ✓ Execute liquidation

(index)	Coverage	Maturity(WFIL)	PV(WFIL)	Deposit(WFIL)	Deposit(ETH)	Deposit(USDC)

User(Before)	'20000'	2050963200	'-262903452624285175371'	'262903452624285175371'	'0'	'1999856430'
User(After)	'115792089237316195423570985008687907853269984665640564039457584007913129639935'	2050963200	'-88118373118276409783'	'262903452624285175371'	'0'	'0'
User(After2)	'26813'	2050963200	'-88118373118276409783'	'262903452624285175371'	'0'	'499964107'

✓ Cancel an order

Liquidations on multiple market

(index)	Coverage	Maturity(WFIL)	Maturity(USDC)	PV(WFIL)	PV(USDC)	Deposit(WFIL)	Deposit(ETH)	Deposit(USDC)
Before1	'7775'	2066688000	2066688000	'-20000000000000000000'	'-600000000'	'0'	'1750000000000000000'	'0'
Before2	'8210'	2066688000	2066688000	'-20000000000000000000'	'-600000000'	'0'	'1750000000000000000'	'0'
After	'7321'	2066688000	2066688000	'-28293910964595707418'	'-600000000'	'0'	'981284090120000000'	'0'

✓ Take orders from both FIL & USDC markets, Liquidate the larger position

(index)	Coverage	Maturity(WFIL)	Maturity(USDC)	PV(WFIL)	PV(USDC)	Deposit(WFIL)	Deposit(ETH)	Deposit(USDC)
Before1	'7775'	2074550400	2074550400	'-20000000000000000000'	'-600000000'	'0'	'1750000000000000000'	'0'
Before2	'8210'	2074550400	2074550400	'-20000000000000000000'	'-600000000'	'0'	'1750000000000000000'	'0'
After	'7552'	2074550400	2074550400	'-20000000000000000000'	'0'	'0'	'1107953910820000000'	'0'

✓ Take orders from both FIL & USDC markets, Liquidate the smaller position

Delisting

Repay and redeem positions

✓ Create orders

✓ Delist a currency

(index)	Coverage	Maturity(WFIL)	PV(WFIL)	Deposit(WFIL)	Deposit(ETH)	Deposit(USDC)
Before	'3803'	2082412800	'-20000000000000000000'	'20000000000000000000'	'2000000000000000000'	'0'
After	'0'	2082412800	'0'	'0'	'2000000000000000000'	'0'

✓ Execute repayment & redemption

Force a repayment of a borrowing position

✓ Create orders

✓ Withdraw

(index)	Coverage	Maturity(WFIL)	PV(WFIL)	Deposit(WFIL)	Deposit(ETH)	Deposit(USDC)
Before	'3803'	2090275200	'-20000000000000000000'	'0'	'2000000000000000000'	'0'
After	'0'	2090275200	'0'	'0'	'1152096846041666667'	'0'

✓ Execute forced repayment

Force a repayment of a insolvent borrowing position

✓ Create orders

✓ Withdraw

(index)	Coverage				
	Maturity(WFIL)	PV(WFIL)	Deposit(WFIL)	Deposit(ETH)	Deposit(USDC)
Before	'-20000000000000000000'	'0'	'2000000000000000000'	'0'	2098137600
After	'11579208923731619542357098500868790785326998466564056403945758400791312963993 5'	'-39754086019483321679'	'0'	'0'	2098137600

✓ Execute forced repayment

Force a repayment of a borrowing position after auto-roll

✓ Create orders

✓ Withdraw

✓ Execute auto-roll

(index)	Coverage	Maturity(WFIL)	PV(WFIL)	Deposit(WFIL)	Deposit(ETH)	Deposit(USDC)
Before	'3574'	2113862400	'-187948767123287671216'	'0'	'2000000000000000000'	'0'
After	'0'	2113862400	'0'	'0'	'1203188237867920378'	'0'

✓ Execute forced repayment

Force a repayment of a insolvent borrowing position after auto-roll

✓ Create orders

✓ Withdraw

✓ Execute auto-roll

(index)	Coverage				
	Maturity(WFIL)	PV(WFIL)	Deposit(WFIL)	Deposit(ETH)	Deposit(USDC)
Before	'-208831963470319634690'	'0'	'2000000000000000000'	'0'	2129587200
After	'11579208923731619542357098500868790785326998466564056403945758400791312963993 5'	'-48586049489802956384'	'0'	'0'	2129587200

✓ Execute forced repayment

Integration Test: Order Book

Market orders

Add orders using the same currency as the collateral, Fill the order, Unwind the ETH borrowing order

✓ Create orders

✓ Deposit ETH

✓ Fill an order on the ETH market

✓ Check collateral

✓ Unwind all positions

Add orders using the different currency as the collateral, Fill the order, Unwind the non-ETH borrowing order

✓ Deposit ETH

✓ Fill an order on the FIL market

✓ Check collateral

✓ Unwind all positions

Fill the order, Unwind the lending order

✓ Deposit ETH

✓ Fill an order on the FIL market

✓ Check lending position

```
      ✓ Unwind a lending position
    Fill orders in multiple markets, Unwind partially
      ✓ Deposit ETH
      ✓ Fill an order on the FIL market
      ✓ Fill an order on the ETH market
      ✓ Check collateral
      ✓ Unwind positions partially
    Fill multiple orders on different order sides in multiple markets
      ✓ Deposit ETH
      ✓ Fill an order on the ETH market(1)
      ✓ Fill an order on the ETH market(2)
    Fill orders, Trigger circuit breakers by one order
      ✓ Fill an order to determine the market unit price
      ✓ Deposit ETH
      ✓ Fill orders on the FIL market
    Fill orders, Trigger circuit breakers by multiple orders
      ✓ Deposit ETH
      ✓ Fill an order to determine the market unit price
      ✓ Fill orders on the FIL market
    Unwind lending position used as collateral
      ✓ Deposit ETH
      ✓ Fill an order on the FIL market(1)
      ✓ Fill an order on the FIL market(2)
      ✓ Fail to unwind positions due to insufficient collateral
    Fill orders without prior approval
      ✓ Deposit ETH
      ✓ Fill an order without prior approval
    Fail to execute order due to not enough deposit
      ✓ Fail to execute order due to no deposit in the selected currency
      ✓ Deposit ETH
      ✓ Fail to execute order due to double spend
  Limit orders
    Fill a borrowing order with the same amount
      ✓ Create users
      ✓ Fill an order
      ✓ Check orders
    Fill a borrowing order with less amount
      ✓ Create users
      ✓ Fill an order
      ✓ Check orders
    Fill a borrowing order with greater amount
      ✓ Create users
      ✓ Fill an order
      ✓ Check orders
    Fill a lending order with the same amount
      ✓ Create users
      ✓ Fill an order
      ✓ Check orders
    Fill a lending order with less amount
      ✓ Create users
      ✓ Fill an order
      ✓ Check orders
    Fill a lending order with greater amount
      ✓ Create users
      ✓ Fill an order
      ✓ Check orders
  Order Cancellation
    Place a borrowing order, Cancel orders
      ✓ Deposit ETH
      ✓ Place a borrowing order on the FIL market
      ✓ Cancel an order
    Place a lending order by a user who has a deposit, Cancel orders
      ✓ Deposit ETH
      ✓ Place a lending order on the FIL market
      ✓ Cancel an order

Integration Test: Tokenization
  Settings
    ✓ Check ZC token info of ETH
    ✓ Check ZC perpetual token info of ETH
    ✓ Check ZC token info of USDC
    ✓ Check ZC perpetual token info of USDC
```

```
  Deposit and Withdraw(ETH)
    Withdraw and deposit ZC tokens by the same user
      ✓ Fill an order
      ✓ Withdraw ZC token
      ✓ Deposit ZC token
    Withdraw and deposit ZC tokens by the different user
      ✓ Fill an order
      ✓ Withdraw ZC token
      ✓ Transfer ZC token
      ✓ Deposit ZC token
    Withdraw and deposit ZC perpetual tokens by the same user
      ✓ Fill an order
      ✓ Execute auto roll
      ✓ Withdraw ZC perpetual token
      ✓ Deposit ZC perpetual token
    Withdraw and deposit ZC perpetual tokens by the different user
      ✓ Fill an order
      ✓ Execute auto roll
      ✓ Withdraw ZC perpetual token
      ✓ Transfer ZC perpetual token
      ✓ Deposit ZC perpetual token
    Deposit ZC tokens after maturity date
      ✓ Fill an order
      ✓ Withdraw ZC token
      ✓ Execute auto roll
      ✓ Deposit ZC token
      ✓ Withdraw ZC token
    Withdraw ZC tokens with deposits after using as collateral
      ✓ Fill an order
      ✓ Fill an order using ZC bonds
      ✓ Withdraw ZC token
    Withdraw ZC tokens with additional deposits after using as collateral
      ✓ Fill an order
      ✓ Fill an order using ZC bonds
      ✓ Deposit additional collateral
      ✓ Withdraw ZC token
    Withdraw ZC tokens without deposits after using as collateral
      ✓ Fill an order
      ✓ Fill an order using ZC bonds
      ✓ Withdraw borrowed collateral
      ✓ Withdraw ZC token
    Deposit ZC tokens after the emergency termination
      ✓ Fill an order
      ✓ Withdraw ZC token
      ✓ Execute emergency termination
      ✓ Deposit ZC token
      ✓ Fail to withdraw ZC token
      ✓ Execute forced redemption
  Deposit and Withdraw(USDC)
    Withdraw and deposit ZC tokens by the same user
      ✓ Fill an order
      ✓ Withdraw ZC token
      ✓ Deposit ZC token
    Withdraw and deposit ZC perpetual tokens by the same user
      ✓ Fill an order
      ✓ Execute auto roll
      ✓ Withdraw ZC perpetual token
      ✓ Deposit ZC perpetual token

Performance Test: Auto-rolls
  Execute auto-rolls for 200 years
    ✓ Fill an order
    ✓ Execute auto-roll (1st time)
    ✓ Execute auto-roll (2nd time)
    ✓ Execute auto-roll (3rd time)
    ✓ Execute auto-roll (4th time)
    ✓ Execute auto-roll (5th time)
    ✓ Execute auto-roll (6th time)
    ✓ Execute auto-roll (7th time)
    ✓ Execute auto-roll (8th time)
    ✓ Execute auto-roll (9th time)
    ✓ Execute auto-roll (10th time)
```

✓ Execute auto-roll (11th time)
✓ Execute auto-roll (12th time)
✓ Execute auto-roll (13th time)
✓ Execute auto-roll (14th time)
✓ Execute auto-roll (15th time)
✓ Execute auto-roll (16th time)
✓ Execute auto-roll (17th time)
✓ Execute auto-roll (18th time)
✓ Execute auto-roll (19th time)
✓ Execute auto-roll (20th time)
✓ Execute auto-roll (21st time)
✓ Execute auto-roll (22nd time)
✓ Execute auto-roll (23rd time)
✓ Execute auto-roll (24th time)
✓ Execute auto-roll (25th time)
✓ Execute auto-roll (26th time)
✓ Execute auto-roll (27th time)
✓ Execute auto-roll (28th time)
✓ Execute auto-roll (29th time)
✓ Execute auto-roll (30th time)
✓ Execute auto-roll (31st time)
✓ Execute auto-roll (32nd time)
✓ Execute auto-roll (33rd time)
✓ Execute auto-roll (34th time)
✓ Execute auto-roll (35th time)
✓ Execute auto-roll (36th time)
✓ Execute auto-roll (37th time)
✓ Execute auto-roll (38th time)
✓ Execute auto-roll (39th time)
✓ Execute auto-roll (40th time)
✓ Execute auto-roll (41st time)
✓ Execute auto-roll (42nd time)
✓ Execute auto-roll (43rd time)
✓ Execute auto-roll (44th time)
✓ Execute auto-roll (45th time)
✓ Execute auto-roll (46th time)
✓ Execute auto-roll (47th time)
✓ Execute auto-roll (48th time)
✓ Execute auto-roll (49th time)
✓ Execute auto-roll (50th time)
✓ Execute auto-roll (51st time)
✓ Execute auto-roll (52nd time)
✓ Execute auto-roll (53rd time)
✓ Execute auto-roll (54th time)
✓ Execute auto-roll (55th time)
✓ Execute auto-roll (56th time)
✓ Execute auto-roll (57th time)
✓ Execute auto-roll (58th time)
✓ Execute auto-roll (59th time)
✓ Execute auto-roll (60th time)
✓ Execute auto-roll (61st time)
✓ Execute auto-roll (62nd time)
✓ Execute auto-roll (63rd time)
✓ Execute auto-roll (64th time)
✓ Execute auto-roll (65th time)
✓ Execute auto-roll (66th time)
✓ Execute auto-roll (67th time)
✓ Execute auto-roll (68th time)
✓ Execute auto-roll (69th time)
✓ Execute auto-roll (70th time)
✓ Execute auto-roll (71st time)
✓ Execute auto-roll (72nd time)
✓ Execute auto-roll (73rd time)
✓ Execute auto-roll (74th time)
✓ Execute auto-roll (75th time)
✓ Execute auto-roll (76th time)
✓ Execute auto-roll (77th time)
✓ Execute auto-roll (78th time)
✓ Execute auto-roll (79th time)
✓ Execute auto-roll (80th time)
✓ Execute auto-roll (81st time)
✓ Execute auto-roll (82nd time)

✓ Execute auto-roll (83rd time)
✓ Execute auto-roll (84th time)
✓ Execute auto-roll (85th time)
✓ Execute auto-roll (86th time)
✓ Execute auto-roll (87th time)
✓ Execute auto-roll (88th time)
✓ Execute auto-roll (89th time)
✓ Execute auto-roll (90th time)
✓ Execute auto-roll (91st time)
✓ Execute auto-roll (92nd time)
✓ Execute auto-roll (93rd time)
✓ Execute auto-roll (94th time)
✓ Execute auto-roll (95th time)
✓ Execute auto-roll (96th time)
✓ Execute auto-roll (97th time)
✓ Execute auto-roll (98th time)
✓ Execute auto-roll (99th time)
✓ Execute auto-roll (100th time)
✓ Execute auto-roll (101st time)
✓ Execute auto-roll (102nd time)
✓ Execute auto-roll (103rd time)
✓ Execute auto-roll (104th time)
✓ Execute auto-roll (105th time)
✓ Execute auto-roll (106th time)
✓ Execute auto-roll (107th time)
✓ Execute auto-roll (108th time)
✓ Execute auto-roll (109th time)
✓ Execute auto-roll (110th time)
✓ Execute auto-roll (111th time)
✓ Execute auto-roll (112th time)
✓ Execute auto-roll (113th time)
✓ Execute auto-roll (114th time)
✓ Execute auto-roll (115th time)
✓ Execute auto-roll (116th time)
✓ Execute auto-roll (117th time)
✓ Execute auto-roll (118th time)
✓ Execute auto-roll (119th time)
✓ Execute auto-roll (120th time)
✓ Execute auto-roll (121st time)
✓ Execute auto-roll (122nd time)
✓ Execute auto-roll (123rd time)
✓ Execute auto-roll (124th time)
✓ Execute auto-roll (125th time)
✓ Execute auto-roll (126th time)
✓ Execute auto-roll (127th time)
✓ Execute auto-roll (128th time)
✓ Execute auto-roll (129th time)
✓ Execute auto-roll (130th time)
✓ Execute auto-roll (131st time)
✓ Execute auto-roll (132nd time)
✓ Execute auto-roll (133rd time)
✓ Execute auto-roll (134th time)
✓ Execute auto-roll (135th time)
✓ Execute auto-roll (136th time)
✓ Execute auto-roll (137th time)
✓ Execute auto-roll (138th time)
✓ Execute auto-roll (139th time)
✓ Execute auto-roll (140th time)
✓ Execute auto-roll (141st time)
✓ Execute auto-roll (142nd time)
✓ Execute auto-roll (143rd time)
✓ Execute auto-roll (144th time)
✓ Execute auto-roll (145th time)
✓ Execute auto-roll (146th time)
✓ Execute auto-roll (147th time)
✓ Execute auto-roll (148th time)
✓ Execute auto-roll (149th time)
✓ Execute auto-roll (150th time)
✓ Execute auto-roll (151st time)
✓ Execute auto-roll (152nd time)
✓ Execute auto-roll (153rd time)
✓ Execute auto-roll (154th time)

✓ Execute auto-roll (155th time)
✓ Execute auto-roll (156th time)
✓ Execute auto-roll (157th time)
✓ Execute auto-roll (158th time)
✓ Execute auto-roll (159th time)
✓ Execute auto-roll (160th time)
✓ Execute auto-roll (161st time)
✓ Execute auto-roll (162nd time)
✓ Execute auto-roll (163rd time)
✓ Execute auto-roll (164th time)
✓ Execute auto-roll (165th time)
✓ Execute auto-roll (166th time)
✓ Execute auto-roll (167th time)
✓ Execute auto-roll (168th time)
✓ Execute auto-roll (169th time)
✓ Execute auto-roll (170th time)
✓ Execute auto-roll (171st time)
✓ Execute auto-roll (172nd time)
✓ Execute auto-roll (173rd time)
✓ Execute auto-roll (174th time)
✓ Execute auto-roll (175th time)
✓ Execute auto-roll (176th time)
✓ Execute auto-roll (177th time)
✓ Execute auto-roll (178th time)
✓ Execute auto-roll (179th time)
✓ Execute auto-roll (180th time)
✓ Execute auto-roll (181st time)
✓ Execute auto-roll (182nd time)
✓ Execute auto-roll (183rd time)
✓ Execute auto-roll (184th time)
✓ Execute auto-roll (185th time)
✓ Execute auto-roll (186th time)
✓ Execute auto-roll (187th time)
✓ Execute auto-roll (188th time)
✓ Execute auto-roll (189th time)
✓ Execute auto-roll (190th time)
✓ Execute auto-roll (191st time)
✓ Execute auto-roll (192nd time)
✓ Execute auto-roll (193rd time)
✓ Execute auto-roll (194th time)
✓ Execute auto-roll (195th time)
✓ Execute auto-roll (196th time)
✓ Execute auto-roll (197th time)
✓ Execute auto-roll (198th time)
✓ Execute auto-roll (199th time)
✓ Execute auto-roll (200th time)
✓ Execute auto-roll (201st time)
✓ Execute auto-roll (202nd time)
✓ Execute auto-roll (203rd time)
✓ Execute auto-roll (204th time)
✓ Execute auto-roll (205th time)
✓ Execute auto-roll (206th time)
✓ Execute auto-roll (207th time)
✓ Execute auto-roll (208th time)
✓ Execute auto-roll (209th time)
✓ Execute auto-roll (210th time)
✓ Execute auto-roll (211th time)
✓ Execute auto-roll (212th time)
✓ Execute auto-roll (213th time)
✓ Execute auto-roll (214th time)
✓ Execute auto-roll (215th time)
✓ Execute auto-roll (216th time)
✓ Execute auto-roll (217th time)
✓ Execute auto-roll (218th time)
✓ Execute auto-roll (219th time)
✓ Execute auto-roll (220th time)
✓ Execute auto-roll (221st time)
✓ Execute auto-roll (222nd time)
✓ Execute auto-roll (223rd time)
✓ Execute auto-roll (224th time)
✓ Execute auto-roll (225th time)
✓ Execute auto-roll (226th time)

✓ Execute auto-roll (227th time)
✓ Execute auto-roll (228th time)
✓ Execute auto-roll (229th time)
✓ Execute auto-roll (230th time)
✓ Execute auto-roll (231st time)
✓ Execute auto-roll (232nd time)
✓ Execute auto-roll (233rd time)
✓ Execute auto-roll (234th time)
✓ Execute auto-roll (235th time)
✓ Execute auto-roll (236th time)
✓ Execute auto-roll (237th time)
✓ Execute auto-roll (238th time)
✓ Execute auto-roll (239th time)
✓ Execute auto-roll (240th time)
✓ Execute auto-roll (241st time)
✓ Execute auto-roll (242nd time)
✓ Execute auto-roll (243rd time)
✓ Execute auto-roll (244th time)
✓ Execute auto-roll (245th time)
✓ Execute auto-roll (246th time)
✓ Execute auto-roll (247th time)
✓ Execute auto-roll (248th time)
✓ Execute auto-roll (249th time)
✓ Execute auto-roll (250th time)
✓ Execute auto-roll (251st time)
✓ Execute auto-roll (252nd time)
✓ Execute auto-roll (253rd time)
✓ Execute auto-roll (254th time)
✓ Execute auto-roll (255th time)
✓ Execute auto-roll (256th time)
✓ Execute auto-roll (257th time)
✓ Execute auto-roll (258th time)
✓ Execute auto-roll (259th time)
✓ Execute auto-roll (260th time)
✓ Execute auto-roll (261st time)
✓ Execute auto-roll (262nd time)
✓ Execute auto-roll (263rd time)
✓ Execute auto-roll (264th time)
✓ Execute auto-roll (265th time)
✓ Execute auto-roll (266th time)
✓ Execute auto-roll (267th time)
✓ Execute auto-roll (268th time)
✓ Execute auto-roll (269th time)
✓ Execute auto-roll (270th time)
✓ Execute auto-roll (271st time)
✓ Execute auto-roll (272nd time)
✓ Execute auto-roll (273rd time)
✓ Execute auto-roll (274th time)
✓ Execute auto-roll (275th time)
✓ Execute auto-roll (276th time)
✓ Execute auto-roll (277th time)
✓ Execute auto-roll (278th time)
✓ Execute auto-roll (279th time)
✓ Execute auto-roll (280th time)
✓ Execute auto-roll (281st time)
✓ Execute auto-roll (282nd time)
✓ Execute auto-roll (283rd time)
✓ Execute auto-roll (284th time)
✓ Execute auto-roll (285th time)
✓ Execute auto-roll (286th time)
✓ Execute auto-roll (287th time)
✓ Execute auto-roll (288th time)
✓ Execute auto-roll (289th time)
✓ Execute auto-roll (290th time)
✓ Execute auto-roll (291st time)
✓ Execute auto-roll (292nd time)
✓ Execute auto-roll (293rd time)
✓ Execute auto-roll (294th time)
✓ Execute auto-roll (295th time)
✓ Execute auto-roll (296th time)
✓ Execute auto-roll (297th time)
✓ Execute auto-roll (298th time)

✓ Execute auto-roll (299th time)
✓ Execute auto-roll (300th time)
✓ Execute auto-roll (301st time)
✓ Execute auto-roll (302nd time)
✓ Execute auto-roll (303rd time)
✓ Execute auto-roll (304th time)
✓ Execute auto-roll (305th time)
✓ Execute auto-roll (306th time)
✓ Execute auto-roll (307th time)
✓ Execute auto-roll (308th time)
✓ Execute auto-roll (309th time)
✓ Execute auto-roll (310th time)
✓ Execute auto-roll (311th time)
✓ Execute auto-roll (312th time)
✓ Execute auto-roll (313th time)
✓ Execute auto-roll (314th time)
✓ Execute auto-roll (315th time)
✓ Execute auto-roll (316th time)
✓ Execute auto-roll (317th time)
✓ Execute auto-roll (318th time)
✓ Execute auto-roll (319th time)
✓ Execute auto-roll (320th time)
✓ Execute auto-roll (321st time)
✓ Execute auto-roll (322nd time)
✓ Execute auto-roll (323rd time)
✓ Execute auto-roll (324th time)
✓ Execute auto-roll (325th time)
✓ Execute auto-roll (326th time)
✓ Execute auto-roll (327th time)
✓ Execute auto-roll (328th time)
✓ Execute auto-roll (329th time)
✓ Execute auto-roll (330th time)
✓ Execute auto-roll (331st time)
✓ Execute auto-roll (332nd time)
✓ Execute auto-roll (333rd time)
✓ Execute auto-roll (334th time)
✓ Execute auto-roll (335th time)
✓ Execute auto-roll (336th time)
✓ Execute auto-roll (337th time)
✓ Execute auto-roll (338th time)
✓ Execute auto-roll (339th time)
✓ Execute auto-roll (340th time)
✓ Execute auto-roll (341st time)
✓ Execute auto-roll (342nd time)
✓ Execute auto-roll (343rd time)
✓ Execute auto-roll (344th time)
✓ Execute auto-roll (345th time)
✓ Execute auto-roll (346th time)
✓ Execute auto-roll (347th time)
✓ Execute auto-roll (348th time)
✓ Execute auto-roll (349th time)
✓ Execute auto-roll (350th time)
✓ Execute auto-roll (351st time)
✓ Execute auto-roll (352nd time)
✓ Execute auto-roll (353rd time)
✓ Execute auto-roll (354th time)
✓ Execute auto-roll (355th time)
✓ Execute auto-roll (356th time)
✓ Execute auto-roll (357th time)
✓ Execute auto-roll (358th time)
✓ Execute auto-roll (359th time)
✓ Execute auto-roll (360th time)
✓ Execute auto-roll (361st time)
✓ Execute auto-roll (362nd time)
✓ Execute auto-roll (363rd time)
✓ Execute auto-roll (364th time)
✓ Execute auto-roll (365th time)
✓ Execute auto-roll (366th time)
✓ Execute auto-roll (367th time)
✓ Execute auto-roll (368th time)
✓ Execute auto-roll (369th time)
✓ Execute auto-roll (370th time)

✓ Execute auto-roll (371st time)
✓ Execute auto-roll (372nd time)
✓ Execute auto-roll (373rd time)
✓ Execute auto-roll (374th time)
✓ Execute auto-roll (375th time)
✓ Execute auto-roll (376th time)
✓ Execute auto-roll (377th time)
✓ Execute auto-roll (378th time)
✓ Execute auto-roll (379th time)
✓ Execute auto-roll (380th time)
✓ Execute auto-roll (381st time)
✓ Execute auto-roll (382nd time)
✓ Execute auto-roll (383rd time)
✓ Execute auto-roll (384th time)
✓ Execute auto-roll (385th time)
✓ Execute auto-roll (386th time)
✓ Execute auto-roll (387th time)
✓ Execute auto-roll (388th time)
✓ Execute auto-roll (389th time)
✓ Execute auto-roll (390th time)
✓ Execute auto-roll (391st time)
✓ Execute auto-roll (392nd time)
✓ Execute auto-roll (393rd time)
✓ Execute auto-roll (394th time)
✓ Execute auto-roll (395th time)
✓ Execute auto-roll (396th time)
✓ Execute auto-roll (397th time)
✓ Execute auto-roll (398th time)
✓ Execute auto-roll (399th time)
✓ Execute auto-roll (400th time)
✓ Execute auto-roll (401st time)
✓ Execute auto-roll (402nd time)
✓ Execute auto-roll (403rd time)
✓ Execute auto-roll (404th time)
✓ Execute auto-roll (405th time)
✓ Execute auto-roll (406th time)
✓ Execute auto-roll (407th time)
✓ Execute auto-roll (408th time)
✓ Execute auto-roll (409th time)
✓ Execute auto-roll (410th time)
✓ Execute auto-roll (411th time)
✓ Execute auto-roll (412th time)
✓ Execute auto-roll (413th time)
✓ Execute auto-roll (414th time)
✓ Execute auto-roll (415th time)
✓ Execute auto-roll (416th time)
✓ Execute auto-roll (417th time)
✓ Execute auto-roll (418th time)
✓ Execute auto-roll (419th time)
✓ Execute auto-roll (420th time)
✓ Execute auto-roll (421st time)
✓ Execute auto-roll (422nd time)
✓ Execute auto-roll (423rd time)
✓ Execute auto-roll (424th time)
✓ Execute auto-roll (425th time)
✓ Execute auto-roll (426th time)
✓ Execute auto-roll (427th time)
✓ Execute auto-roll (428th time)
✓ Execute auto-roll (429th time)
✓ Execute auto-roll (430th time)
✓ Execute auto-roll (431st time)
✓ Execute auto-roll (432nd time)
✓ Execute auto-roll (433rd time)
✓ Execute auto-roll (434th time)
✓ Execute auto-roll (435th time)
✓ Execute auto-roll (436th time)
✓ Execute auto-roll (437th time)
✓ Execute auto-roll (438th time)
✓ Execute auto-roll (439th time)
✓ Execute auto-roll (440th time)
✓ Execute auto-roll (441st time)
✓ Execute auto-roll (442nd time)

✓ Execute auto-roll (443rd time)
✓ Execute auto-roll (444th time)
✓ Execute auto-roll (445th time)
✓ Execute auto-roll (446th time)
✓ Execute auto-roll (447th time)
✓ Execute auto-roll (448th time)
✓ Execute auto-roll (449th time)
✓ Execute auto-roll (450th time)
✓ Execute auto-roll (451st time)
✓ Execute auto-roll (452nd time)
✓ Execute auto-roll (453rd time)
✓ Execute auto-roll (454th time)
✓ Execute auto-roll (455th time)
✓ Execute auto-roll (456th time)
✓ Execute auto-roll (457th time)
✓ Execute auto-roll (458th time)
✓ Execute auto-roll (459th time)
✓ Execute auto-roll (460th time)
✓ Execute auto-roll (461st time)
✓ Execute auto-roll (462nd time)
✓ Execute auto-roll (463rd time)
✓ Execute auto-roll (464th time)
✓ Execute auto-roll (465th time)
✓ Execute auto-roll (466th time)
✓ Execute auto-roll (467th time)
✓ Execute auto-roll (468th time)
✓ Execute auto-roll (469th time)
✓ Execute auto-roll (470th time)
✓ Execute auto-roll (471st time)
✓ Execute auto-roll (472nd time)
✓ Execute auto-roll (473rd time)
✓ Execute auto-roll (474th time)
✓ Execute auto-roll (475th time)
✓ Execute auto-roll (476th time)
✓ Execute auto-roll (477th time)
✓ Execute auto-roll (478th time)
✓ Execute auto-roll (479th time)
✓ Execute auto-roll (480th time)
✓ Execute auto-roll (481st time)
✓ Execute auto-roll (482nd time)
✓ Execute auto-roll (483rd time)
✓ Execute auto-roll (484th time)
✓ Execute auto-roll (485th time)
✓ Execute auto-roll (486th time)
✓ Execute auto-roll (487th time)
✓ Execute auto-roll (488th time)
✓ Execute auto-roll (489th time)
✓ Execute auto-roll (490th time)
✓ Execute auto-roll (491st time)
✓ Execute auto-roll (492nd time)
✓ Execute auto-roll (493rd time)
✓ Execute auto-roll (494th time)
✓ Execute auto-roll (495th time)
✓ Execute auto-roll (496th time)
✓ Execute auto-roll (497th time)
✓ Execute auto-roll (498th time)
✓ Execute auto-roll (499th time)
✓ Execute auto-roll (500th time)
✓ Execute auto-roll (501st time)
✓ Execute auto-roll (502nd time)
✓ Execute auto-roll (503rd time)
✓ Execute auto-roll (504th time)
✓ Execute auto-roll (505th time)
✓ Execute auto-roll (506th time)
✓ Execute auto-roll (507th time)
✓ Execute auto-roll (508th time)
✓ Execute auto-roll (509th time)
✓ Execute auto-roll (510th time)
✓ Execute auto-roll (511th time)
✓ Execute auto-roll (512th time)
✓ Execute auto-roll (513th time)
✓ Execute auto-roll (514th time)

✓ Execute auto-roll (515th time)
✓ Execute auto-roll (516th time)
✓ Execute auto-roll (517th time)
✓ Execute auto-roll (518th time)
✓ Execute auto-roll (519th time)
✓ Execute auto-roll (520th time)
✓ Execute auto-roll (521st time)
✓ Execute auto-roll (522nd time)
✓ Execute auto-roll (523rd time)
✓ Execute auto-roll (524th time)
✓ Execute auto-roll (525th time)
✓ Execute auto-roll (526th time)
✓ Execute auto-roll (527th time)
✓ Execute auto-roll (528th time)
✓ Execute auto-roll (529th time)
✓ Execute auto-roll (530th time)
✓ Execute auto-roll (531st time)
✓ Execute auto-roll (532nd time)
✓ Execute auto-roll (533rd time)
✓ Execute auto-roll (534th time)
✓ Execute auto-roll (535th time)
✓ Execute auto-roll (536th time)
✓ Execute auto-roll (537th time)
✓ Execute auto-roll (538th time)
✓ Execute auto-roll (539th time)
✓ Execute auto-roll (540th time)
✓ Execute auto-roll (541st time)
✓ Execute auto-roll (542nd time)
✓ Execute auto-roll (543rd time)
✓ Execute auto-roll (544th time)
✓ Execute auto-roll (545th time)
✓ Execute auto-roll (546th time)
✓ Execute auto-roll (547th time)
✓ Execute auto-roll (548th time)
✓ Execute auto-roll (549th time)
✓ Execute auto-roll (550th time)
✓ Execute auto-roll (551st time)
✓ Execute auto-roll (552nd time)
✓ Execute auto-roll (553rd time)
✓ Execute auto-roll (554th time)
✓ Execute auto-roll (555th time)
✓ Execute auto-roll (556th time)
✓ Execute auto-roll (557th time)
✓ Execute auto-roll (558th time)
✓ Execute auto-roll (559th time)
✓ Execute auto-roll (560th time)
✓ Execute auto-roll (561st time)
✓ Execute auto-roll (562nd time)
✓ Execute auto-roll (563rd time)
✓ Execute auto-roll (564th time)
✓ Execute auto-roll (565th time)
✓ Execute auto-roll (566th time)
✓ Execute auto-roll (567th time)
✓ Execute auto-roll (568th time)
✓ Execute auto-roll (569th time)
✓ Execute auto-roll (570th time)
✓ Execute auto-roll (571st time)
✓ Execute auto-roll (572nd time)
✓ Execute auto-roll (573rd time)
✓ Execute auto-roll (574th time)
✓ Execute auto-roll (575th time)
✓ Execute auto-roll (576th time)
✓ Execute auto-roll (577th time)
✓ Execute auto-roll (578th time)
✓ Execute auto-roll (579th time)
✓ Execute auto-roll (580th time)
✓ Execute auto-roll (581st time)
✓ Execute auto-roll (582nd time)
✓ Execute auto-roll (583rd time)
✓ Execute auto-roll (584th time)
✓ Execute auto-roll (585th time)
✓ Execute auto-roll (586th time)

✓ Execute auto-roll (587th time)
✓ Execute auto-roll (588th time)
✓ Execute auto-roll (589th time)
✓ Execute auto-roll (590th time)
✓ Execute auto-roll (591st time)
✓ Execute auto-roll (592nd time)
✓ Execute auto-roll (593rd time)
✓ Execute auto-roll (594th time)
✓ Execute auto-roll (595th time)
✓ Execute auto-roll (596th time)
✓ Execute auto-roll (597th time)
✓ Execute auto-roll (598th time)
✓ Execute auto-roll (599th time)
✓ Execute auto-roll (600th time)
✓ Execute auto-roll (601st time)
✓ Execute auto-roll (602nd time)
✓ Execute auto-roll (603rd time)
✓ Execute auto-roll (604th time)
✓ Execute auto-roll (605th time)
✓ Execute auto-roll (606th time)
✓ Execute auto-roll (607th time)
✓ Execute auto-roll (608th time)
✓ Execute auto-roll (609th time)
✓ Execute auto-roll (610th time)
✓ Execute auto-roll (611th time)
✓ Execute auto-roll (612th time)
✓ Execute auto-roll (613th time)
✓ Execute auto-roll (614th time)
✓ Execute auto-roll (615th time)
✓ Execute auto-roll (616th time)
✓ Execute auto-roll (617th time)
✓ Execute auto-roll (618th time)
✓ Execute auto-roll (619th time)
✓ Execute auto-roll (620th time)
✓ Execute auto-roll (621st time)
✓ Execute auto-roll (622nd time)
✓ Execute auto-roll (623rd time)
✓ Execute auto-roll (624th time)
✓ Execute auto-roll (625th time)
✓ Execute auto-roll (626th time)
✓ Execute auto-roll (627th time)
✓ Execute auto-roll (628th time)
✓ Execute auto-roll (629th time)
✓ Execute auto-roll (630th time)
✓ Execute auto-roll (631st time)
✓ Execute auto-roll (632nd time)
✓ Execute auto-roll (633rd time)
✓ Execute auto-roll (634th time)
✓ Execute auto-roll (635th time)
✓ Execute auto-roll (636th time)
✓ Execute auto-roll (637th time)
✓ Execute auto-roll (638th time)
✓ Execute auto-roll (639th time)
✓ Execute auto-roll (640th time)
✓ Execute auto-roll (641st time)
✓ Execute auto-roll (642nd time)
✓ Execute auto-roll (643rd time)
✓ Execute auto-roll (644th time)
✓ Execute auto-roll (645th time)
✓ Execute auto-roll (646th time)
✓ Execute auto-roll (647th time)
✓ Execute auto-roll (648th time)
✓ Execute auto-roll (649th time)
✓ Execute auto-roll (650th time)
✓ Execute auto-roll (651st time)
✓ Execute auto-roll (652nd time)
✓ Execute auto-roll (653rd time)
✓ Execute auto-roll (654th time)
✓ Execute auto-roll (655th time)
✓ Execute auto-roll (656th time)
✓ Execute auto-roll (657th time)
✓ Execute auto-roll (658th time)

✓ Execute auto-roll (659th time)
✓ Execute auto-roll (660th time)
✓ Execute auto-roll (661st time)
✓ Execute auto-roll (662nd time)
✓ Execute auto-roll (663rd time)
✓ Execute auto-roll (664th time)
✓ Execute auto-roll (665th time)
✓ Execute auto-roll (666th time)
✓ Execute auto-roll (667th time)
✓ Execute auto-roll (668th time)
✓ Execute auto-roll (669th time)
✓ Execute auto-roll (670th time)
✓ Execute auto-roll (671st time)
✓ Execute auto-roll (672nd time)
✓ Execute auto-roll (673rd time)
✓ Execute auto-roll (674th time)
✓ Execute auto-roll (675th time)
✓ Execute auto-roll (676th time)
✓ Execute auto-roll (677th time)
✓ Execute auto-roll (678th time)
✓ Execute auto-roll (679th time)
✓ Execute auto-roll (680th time)
✓ Execute auto-roll (681st time)
✓ Execute auto-roll (682nd time)
✓ Execute auto-roll (683rd time)
✓ Execute auto-roll (684th time)
✓ Execute auto-roll (685th time)
✓ Execute auto-roll (686th time)
✓ Execute auto-roll (687th time)
✓ Execute auto-roll (688th time)
✓ Execute auto-roll (689th time)
✓ Execute auto-roll (690th time)
✓ Execute auto-roll (691st time)
✓ Execute auto-roll (692nd time)
✓ Execute auto-roll (693rd time)
✓ Execute auto-roll (694th time)
✓ Execute auto-roll (695th time)
✓ Execute auto-roll (696th time)
✓ Execute auto-roll (697th time)
✓ Execute auto-roll (698th time)
✓ Execute auto-roll (699th time)
✓ Execute auto-roll (700th time)
✓ Execute auto-roll (701st time)
✓ Execute auto-roll (702nd time)
✓ Execute auto-roll (703rd time)
✓ Execute auto-roll (704th time)
✓ Execute auto-roll (705th time)
✓ Execute auto-roll (706th time)
✓ Execute auto-roll (707th time)
✓ Execute auto-roll (708th time)
✓ Execute auto-roll (709th time)
✓ Execute auto-roll (710th time)
✓ Execute auto-roll (711th time)
✓ Execute auto-roll (712th time)
✓ Execute auto-roll (713th time)
✓ Execute auto-roll (714th time)
✓ Execute auto-roll (715th time)
✓ Execute auto-roll (716th time)
✓ Execute auto-roll (717th time)
✓ Execute auto-roll (718th time)
✓ Execute auto-roll (719th time)
✓ Execute auto-roll (720th time)
✓ Execute auto-roll (721st time)
✓ Execute auto-roll (722nd time)
✓ Execute auto-roll (723rd time)
✓ Execute auto-roll (724th time)
✓ Execute auto-roll (725th time)
✓ Execute auto-roll (726th time)
✓ Execute auto-roll (727th time)
✓ Execute auto-roll (728th time)
✓ Execute auto-roll (729th time)
✓ Execute auto-roll (730th time)

✓ Execute auto-roll (731st time)
✓ Execute auto-roll (732nd time)
✓ Execute auto-roll (733rd time)
✓ Execute auto-roll (734th time)
✓ Execute auto-roll (735th time)
✓ Execute auto-roll (736th time)
✓ Execute auto-roll (737th time)
✓ Execute auto-roll (738th time)
✓ Execute auto-roll (739th time)
✓ Execute auto-roll (740th time)
✓ Execute auto-roll (741st time)
✓ Execute auto-roll (742nd time)
✓ Execute auto-roll (743rd time)
✓ Execute auto-roll (744th time)
✓ Execute auto-roll (745th time)
✓ Execute auto-roll (746th time)
✓ Execute auto-roll (747th time)
✓ Execute auto-roll (748th time)
✓ Execute auto-roll (749th time)
✓ Execute auto-roll (750th time)
✓ Execute auto-roll (751st time)
✓ Execute auto-roll (752nd time)
✓ Execute auto-roll (753rd time)
✓ Execute auto-roll (754th time)
✓ Execute auto-roll (755th time)
✓ Execute auto-roll (756th time)
✓ Execute auto-roll (757th time)
✓ Execute auto-roll (758th time)
✓ Execute auto-roll (759th time)
✓ Execute auto-roll (760th time)
✓ Execute auto-roll (761st time)
✓ Execute auto-roll (762nd time)
✓ Execute auto-roll (763rd time)
✓ Execute auto-roll (764th time)
✓ Execute auto-roll (765th time)
✓ Execute auto-roll (766th time)
✓ Execute auto-roll (767th time)
✓ Execute auto-roll (768th time)
✓ Execute auto-roll (769th time)
✓ Execute auto-roll (770th time)
✓ Execute auto-roll (771st time)
✓ Execute auto-roll (772nd time)
✓ Execute auto-roll (773rd time)
✓ Execute auto-roll (774th time)
✓ Execute auto-roll (775th time)
✓ Execute auto-roll (776th time)
✓ Execute auto-roll (777th time)
✓ Execute auto-roll (778th time)
✓ Execute auto-roll (779th time)
✓ Execute auto-roll (780th time)
✓ Execute auto-roll (781st time)
✓ Execute auto-roll (782nd time)
✓ Execute auto-roll (783rd time)
✓ Execute auto-roll (784th time)
✓ Execute auto-roll (785th time)
✓ Execute auto-roll (786th time)
✓ Execute auto-roll (787th time)
✓ Execute auto-roll (788th time)
✓ Execute auto-roll (789th time)
✓ Execute auto-roll (790th time)
✓ Execute auto-roll (791st time)
✓ Execute auto-roll (792nd time)
✓ Execute auto-roll (793rd time)
✓ Execute auto-roll (794th time)
✓ Execute auto-roll (795th time)
✓ Execute auto-roll (796th time)
✓ Execute auto-roll (797th time)
✓ Execute auto-roll (798th time)
✓ Execute auto-roll (799th time)
✓ Execute auto-roll (800th time)
✓ Check the orders
✓ Clean up orders

```
      ✓ Fill an order

  Performance Test: Order Book
    Fill orders without the order cleaning
      ETH market
        Ordered: 0
[K        Ordered: 0/1
[K        ✓ 1 orders
        Ordered: 0
[K        Ordered: 0/10
[K        Ordered: 1/10
[K        Ordered: 2/10
[K        Ordered: 3/10
[K        Ordered: 4/10
[K        Ordered: 5/10
[K        Ordered: 6/10
[K        Ordered: 7/10
[K        Ordered: 8/10
[K        Ordered: 9/10
[K        ✓ 10 orders
        Ordered: 0
[K        Ordered: 0/100
[K        Ordered: 1/100
[K        Ordered: 2/100
[K        Ordered: 3/100
[K        Ordered: 4/100
[K        Ordered: 5/100
[K        Ordered: 6/100
[K        Ordered: 7/100
[K        Ordered: 8/100
[K        Ordered: 9/100
[K        Ordered: 10/100
[K        Ordered: 11/100
[K        Ordered: 12/100
[K        Ordered: 13/100
[K        Ordered: 14/100
[K        Ordered: 15/100
[K        Ordered: 16/100
[K        Ordered: 17/100
[K        Ordered: 18/100
[K        Ordered: 19/100
[K        Ordered: 20/100
[K        Ordered: 21/100
[K        Ordered: 22/100
[K        Ordered: 23/100
[K        Ordered: 24/100
[K        Ordered: 25/100
[K        Ordered: 26/100
[K        Ordered: 27/100
[K        Ordered: 28/100
[K        Ordered: 29/100
[K        Ordered: 30/100
[K        Ordered: 31/100
[K        Ordered: 32/100
[K        Ordered: 33/100
[K        Ordered: 34/100
[K        Ordered: 35/100
[K        Ordered: 36/100
[K        Ordered: 37/100
[K        Ordered: 38/100
[K        Ordered: 39/100
[K        Ordered: 40/100
[K        Ordered: 41/100
[K        Ordered: 42/100
[K        Ordered: 43/100
[K        Ordered: 44/100
[K        Ordered: 45/100
[K        Ordered: 46/100
[K        Ordered: 47/100
[K        Ordered: 48/100
[K        Ordered: 49/100
[K        Ordered: 50/100
```

```
[K        Ordered: 51/100
[K        Ordered: 52/100
[K        Ordered: 53/100
[K        Ordered: 54/100
[K        Ordered: 55/100
[K        Ordered: 56/100
[K        Ordered: 57/100
[K        Ordered: 58/100
[K        Ordered: 59/100
[K        Ordered: 60/100
[K        Ordered: 61/100
[K        Ordered: 62/100
[K        Ordered: 63/100
[K        Ordered: 64/100
[K        Ordered: 65/100
[K        Ordered: 66/100
[K        Ordered: 67/100
[K        Ordered: 68/100
[K        Ordered: 69/100
[K        Ordered: 70/100
[K        Ordered: 71/100
[K        Ordered: 72/100
[K        Ordered: 73/100
[K        Ordered: 74/100
[K        Ordered: 75/100
[K        Ordered: 76/100
[K        Ordered: 77/100
[K        Ordered: 78/100
[K        Ordered: 79/100
[K        Ordered: 80/100
[K        Ordered: 81/100
[K        Ordered: 82/100
[K        Ordered: 83/100
[K        Ordered: 84/100
[K        Ordered: 85/100
[K        Ordered: 86/100
[K        Ordered: 87/100
[K        Ordered: 88/100
[K        Ordered: 89/100
[K        Ordered: 90/100
[K        Ordered: 91/100
[K        Ordered: 92/100
[K        Ordered: 93/100
[K        Ordered: 94/100
[K        Ordered: 95/100
[K        Ordered: 96/100
[K        Ordered: 97/100
[K        Ordered: 98/100
[K        Ordered: 99/100
[K        ✓ 100 orders
     USDC market
       Ordered: 0
[K        Ordered: 0/1
[K        ✓ 1 orders
       Ordered: 0
[K        Ordered: 0/10
[K        Ordered: 1/10
[K        Ordered: 2/10
[K        Ordered: 3/10
[K        Ordered: 4/10
[K        Ordered: 5/10
[K        Ordered: 6/10
[K        Ordered: 7/10
[K        Ordered: 8/10
[K        Ordered: 9/10
[K        ✓ 10 orders
       Ordered: 0
[K        Ordered: 0/100
[K        Ordered: 1/100
[K        Ordered: 2/100
[K        Ordered: 3/100
[K        Ordered: 4/100
```

```
[K        Ordered: 5/100
[K        Ordered: 6/100
[K        Ordered: 7/100
[K        Ordered: 8/100
[K        Ordered: 9/100
[K        Ordered: 10/100
[K        Ordered: 11/100
[K        Ordered: 12/100
[K        Ordered: 13/100
[K        Ordered: 14/100
[K        Ordered: 15/100
[K        Ordered: 16/100
[K        Ordered: 17/100
[K        Ordered: 18/100
[K        Ordered: 19/100
[K        Ordered: 20/100
[K        Ordered: 21/100
[K        Ordered: 22/100
[K        Ordered: 23/100
[K        Ordered: 24/100
[K        Ordered: 25/100
[K        Ordered: 26/100
[K        Ordered: 27/100
[K        Ordered: 28/100
[K        Ordered: 29/100
[K        Ordered: 30/100
[K        Ordered: 31/100
[K        Ordered: 32/100
[K        Ordered: 33/100
[K        Ordered: 34/100
[K        Ordered: 35/100
[K        Ordered: 36/100
[K        Ordered: 37/100
[K        Ordered: 38/100
[K        Ordered: 39/100
[K        Ordered: 40/100
[K        Ordered: 41/100
[K        Ordered: 42/100
[K        Ordered: 43/100
[K        Ordered: 44/100
[K        Ordered: 45/100
[K        Ordered: 46/100
[K        Ordered: 47/100
[K        Ordered: 48/100
[K        Ordered: 49/100
[K        Ordered: 50/100
[K        Ordered: 51/100
[K        Ordered: 52/100
[K        Ordered: 53/100
[K        Ordered: 54/100
[K        Ordered: 55/100
[K        Ordered: 56/100
[K        Ordered: 57/100
[K        Ordered: 58/100
[K        Ordered: 59/100
[K        Ordered: 60/100
[K        Ordered: 61/100
[K        Ordered: 62/100
[K        Ordered: 63/100
[K        Ordered: 64/100
[K        Ordered: 65/100
[K        Ordered: 66/100
[K        Ordered: 67/100
[K        Ordered: 68/100
[K        Ordered: 69/100
[K        Ordered: 70/100
[K        Ordered: 71/100
[K        Ordered: 72/100
[K        Ordered: 73/100
[K        Ordered: 74/100
[K        Ordered: 75/100
[K        Ordered: 76/100
```

```
[K        Ordered: 77/100
[K        Ordered: 78/100
[K        Ordered: 79/100
[K        Ordered: 80/100
[K        Ordered: 81/100
[K        Ordered: 82/100
[K        Ordered: 83/100
[K        Ordered: 84/100
[K        Ordered: 85/100
[K        Ordered: 86/100
[K        Ordered: 87/100
[K        Ordered: 88/100
[K        Ordered: 89/100
[K        Ordered: 90/100
[K        Ordered: 91/100
[K        Ordered: 92/100
[K        Ordered: 93/100
[K        Ordered: 94/100
[K        Ordered: 95/100
[K        Ordered: 96/100
[K        Ordered: 97/100
[K        Ordered: 98/100
[K        Ordered: 99/100
[K        ✓ 100 orders
     Show results
```

(index)	GasCosts(ETH)	GasCosts(USDC)
1	854025	951688
10	539392	670265
100	1487429	1614031

```
       ✓ Gas Costs
   Place an order with the order cleaning
     USDC market
       Ordered: 0
[K        Ordered: 0/1
[K        ✓ 1 markets
       Ordered: 0
[K        Ordered: 0/2
[K        Ordered: 1/2
[K        ✓ 2 markets
       Ordered: 0
[K        Ordered: 0/8
[K        Ordered: 1/8
[K        Ordered: 2/8
[K        Ordered: 3/8
[K        Ordered: 4/8
[K        Ordered: 5/8
[K        Ordered: 6/8
[K        Ordered: 7/8
[K        ✓ 8 markets
     Show results
```

(index)	GasCosts
1	526210
2	692385
8	852112

```
       ✓ Gas Costs
   Place an order with active orders
     USDC market
       ✓ Deposit
       ✓ Active orders: 0
       ✓ Active orders: 1
       ✓ Active orders: 2
       ✓ Active orders: 3
       ✓ Active orders: 4
       ✓ Active orders: 5
       ✓ Active orders: 6
       ✓ Active orders: 7
```

```
      ✓ Active orders: 8
      ✓ Active orders: 9
      ✓ Active orders: 10
      ✓ Active orders: 11
      ✓ Active orders: 12
      ✓ Active orders: 13
      ✓ Active orders: 14
      ✓ Active orders: 15
      ✓ Active orders: 16
      ✓ Active orders: 17
      ✓ Active orders: 18
      ✓ Active orders: 19
    Show results
```

(index)	GasCosts(USDC)
0	793440
1	611658
2	702897
3	669726
4	732100
5	739975
6	788125
7	823340
8	838254
9	839309
10	912532
11	914224
12	949622
13	952597
14	1014394
15	1050281
16	1074832
17	1122170
18	1125787
19	1140967

```
      ✓ Gas Costs

  AddressResolver
    Ownership
      ✓ Transfer ownership
      ✓ Renounce ownership
      ✓ Fail to renounce ownership due to execution by non-owner
      ✓ Fail to transfer ownership due execution by non-owner
      ✓ Fail to transfer ownership due to zero address
    Initialization
      ✓ Fail to call initialization due to duplicate execution
      ✓ Fail to call initialization due to execution by non-proxy contract
    Address importing
      ✓ Import empty array
      ✓ Import an address
      ✓ Import multiple addresses
      ✓ Import an addresses multiple times with different contract
      ✓ Fail to import an addresses due to unmatched inputs
      ✓ Fail to import an addresses due to execution by non-owner
    Imported address check
      ✓ Get an empty address
      ✓ Get a imported address
      ✓ Get multiple imported addresses
      ✓ Fail to get a imported address due to non-exist contract

  BeaconProxyController
    Initialization
      ✓ Check if the contract addresses are cached in the resolver
      ✓ Fail to call initialization due to duplicate execution
      ✓ Fail to call initialization due to execution by non-proxy contract
    Get data
      ✓ Get the required contracts
      ✓ Fail to get the beacon proxy address due to empty address
    FutureValueVault implementation
      ✓ Set an implementation contract and deploy the contract
```

```
    ✓ Set an implementation contract twice
    ✓ Fail to set an implementation contract due to execution by non-owner
    ✓ Fail to deploy the contract due to execution by non-accepted contract
    ✓ Fail to deploy the contract due to non-existence of beacon proxy contract
  LendingMarket implementation
    ✓ Set an implementation contract and deploy the contract
    ✓ Set an implementation contract twice
    ✓ Fail to set an implementation contract due to execution by non-owner
    ✓ Fail to deploy the contract due to execution by non-accepted contract
    ✓ Fail to deploy the contract due to non-existence of beacon proxy contract
  Change Admin
    ✓ Successfully change admins of a beacon proxy contract
    ✓ Fail to change admins of a beacon proxy contract due to execution by non-owner

CurrencyController
  Initialization
    ✓ Add a currency except for ETH as a supported currency
    ✓ Fail to add a currency due to the invalid price
    ✓ Fail to add a currency due to the invalid decimals
    ✓ Fail to add a currency due to the mismatch of price feeds decimals with the base currency
    ✓ Fail to add a currency due to empty price feed
    ✓ Fail to add a currency due to input array length mismatch
    ✓ Fail to add a currency due to execution by non-owner
    ✓ Fail to call initialization due to duplicate execution
    ✓ Fail to call initialization due to execution by non-proxy contract
  Update
    ✓ Update a currency support
    ✓ Update a haircut
    ✓ Update a price feed
    ✓ Update multiple price feeds
    ✓ Update multiple data using multicall
    ✓ Fail to update the haircut due to overflow
    ✓ Fail to update the haircut due to invalid currency
    ✓ Fail to update the price feed due to invalid currency
    ✓ Fail to update the price feed due to input array length mismatch
    ✓ Fail to remove the currency due to execution by non-owner
    ✓ Fail to update the haircut due to execution by non-owner
    ✓ Fail to update the price feed due to execution by non-owner
    ✓ Fail to update the price feed due to stale price feed with old timestamp
    ✓ Fail to update the price feed due to stale price feed with zero price
  Convert
    ✓ Get the converted amount(int256) in the base currency
    ✓ Get the converted amount(uint256) in the base currency
    ✓ Get the array of converted amounts(uint256[]) in the base currency
    ✓ Get the converted amount(uint256) in the selected currency
    ✓ Get the converted amount(uint256) in the selected currency
    ✓ Get the converted amount in the selected currency from another selected currency
    ✓ Get the converted amounts in the selected currency from another selected currency
    ✓ Get the converted amounts in the selected currency from another selected currency from 0
    ✓ Fail to get the converted amount due to stale price feed with old timestamp
    ✓ Fail to get the converted amount due to stale price feed with zero price

FutureValueVault
  Initialization
    ✓ Fail to call initialization due to duplicate execution
    ✓ Fail to call initialization due to execution by non-beacon proxy contract
  Update balance
    ✓ Increase user balance
    ✓ Decrease user balance
    ✓ Fail to increase balance due to execution by non-accepted contract
    ✓ Fail to decrease balance due to execution by non-accepted contract
    ✓ Fail to increase balance due to invalid user address
    ✓ Fail to decrease balance due to invalid user address
  Lock and unlock balance
    ✓ Lock user balance
    ✓ Unlock user balance
    ✓ Fail to lock user balance if balance is minus
    ✓ Fail to lock user balance if balance is 0
    ✓ Fail to unlock user balance if total unlock balance is insufficient
    ✓ Fail to lock balance due to execution by non-accepted contract
    ✓ Fail to unlock balance due to execution by non-accepted contract
  Transfer balance
```

```
    ✓ Transfer balance to another user
    ✓ Fail to transfer balance because sender has balance in the past maturity
    ✓ Fail to transfer balance because receiver has balance in the past maturity
    ✓ Fail to transfer balance due to execution by non-accepted contract
  Reset balance
    ✓ Force reset a user's empty balance with amount
    ✓ Force reset a user's balance with amount
    ✓ Force reset a user's empty balance without amount
    ✓ Force reset a user's balance with amount
    ✓ Fail to force reset a user's balance due to lending amount mismatch
    ✓ Fail to force reset a user's balance due to borrowing amount mismatch
    ✓ Fail to force reset a user's balance with amount due to execution by non-accepted contract
    ✓ Fail to force reset a user's balance without amount due to execution by non-accepted contract

GenesisValueVault
  Initialize
    ✓ Initialize contract settings
    ✓ Fail to call initialization due to duplicate execution
    ✓ Fail to call initialization due to execution by non-proxy contract
    ✓ Fail to initialize the currency setting due to execution by non-accepted contract
    ✓ Fail to update the initial compound factor due to execution by non-accepted contract
    ✓ Fail to initialize the currency setting due to zero compound factor
    ✓ Fail to initialize the currency setting due to the initialized
    ✓ Fail to update the initial compound factor due to the finalized
  Balance
    Calculate balance
      ✓ Convert balance to selected maturity from another maturity
      ✓ Convert 0 to selected maturity from another maturity
      ✓ Convert balance to selected maturity from same maturity
      ✓ Calculate amount in FV from positive amount in GV
      ✓ Calculate amount in FV from negative amount in GV
      ✓ Fail to calculate amount in FV from amount in GV due to no compound factor
      ✓ Fail to calculate amount in GV from amount in FV due to no compound factor
    Update balance
      ✓ Update the genesis value
      ✓ Update the genesis value after auto-rolls
      ✓ Update the genesis value with residual amount
      ✓ Update the genesis value from a positive amount to a negative amount
      ✓ Update the genesis value from a negative amount to a positive amount
      ✓ Fail to update the genesis value due to execution by non-accepted contract
      ✓ Fail to update the genesis value with residual amount due to execution by non-accepted contract
    Lock and unlock balance
      ✓ Lock user balance
      ✓ Unlock user balance
      ✓ Fail to lock user balance if balance is minus
      ✓ Fail to lock user balance if balance is 0
      ✓ Fail to unlock user balance if if total unlock balance is insufficient
      ✓ Fail to lock user balance due to execution by non-accepted contract
      ✓ Fail to unlock user balance due to execution by non-accepted contract
    Transfer balance
      ✓ Transfer balance to another user
      ✓ Fail to transfer balance to another user due to execution by non-accepted contract
    Reset balance
      ✓ Force reset a user's empty balance with amount
      ✓ Force reset a user's empty balance with small amount
      ✓ Force reset a user's empty balance without amount
      ✓ Fail to force reset a user's balance due to lending amount mismatch
      ✓ Fail to force reset a user's balance due to borrowing amount mismatch
      ✓ Fail to force reset a user's balance without amount due to execution by non-accepted contract
      ✓ Fail to force reset a user's balance with amount due to execution by non-accepted contract
    Clean up balance
      ✓ Clean up a user balance
      ✓ Clean up a user balance with fluctuation
      ✓ Fail to clean up a user balance due to execution by non-accepted contract
  Auto-roll
    ✓ Execute auto-roll
    ✓ Calculate the balance fluctuation of auto-rolls by on the current maturity
    ✓ Calculate the balance fluctuation of auto-rolls by on the future maturity
    ✓ Calculate the balance fluctuation of auto-rolls by on the past maturity
    ✓ Calculate the balance fluctuation of auto-rolls with invalid maturity
    ✓ Fail to execute auto-roll due to duplicate execution
    ✓ Fail to execute auto-roll due to execution by non-accepted contract
```

```
    ✓ Fail to execute auto-roll due to invalid order fee rate
    ✓ Fail to execute auto-roll due to zero unit price
    ✓ Fail to execute auto-roll due to invalid maturity

LendingMarket - Auto-rolls
  ✓ Execute an auto-roll
  ✓ Fail to execute an auto-roll due to invalid caller
  ✓ Fail to execute an auto-roll due to invalid caller

LendingMarket - Calculations
  ✓ Calculate the filled amount from one lending order
  ✓ Calculate the filled amount from one borrowing order
  ✓ Calculate the filled amount from multiple lending order
  ✓ Calculate the filled amount from multiple borrowing order
  ✓ Calculate the blocked order amount by the circuit breaker

LendingMarket - Circuit Breakers
  Get circuit breaker thresholds
    ✓ Get circuit breaker thresholds without the last block price
    ✓ Get circuit breaker thresholds with the last block price
  Borrow orders
    ✓ Fill an order partially until the circuit breaker threshold using the market order
    ✓ Fill an order partially until the circuit breaker threshold using the limit order
    ✓ Execute multiple transactions to fill orders in one block with the circuit breaker triggered
    ✓ Fill an order in different blocks after the circuit breaker has been triggered
    ✓ Fill an order in the same block after the circuit breaker has been triggered
    ✓ Fail to place a second market order in the same block due to no filled amount
    ✓ Fail to place a second limit order in the same block due to over the circuit breaker threshold
    ✓ Fill an order within the circuit breaker minimum rage
    ✓ Fill an order outside the circuit breaker minimum rage
    ✓ Fill an order within the circuit breaker that has reached min unit price
  Lend orders
    ✓ Fill an order partially until the circuit breaker threshold using the market order
    ✓ Fill an order partially until the circuit breaker threshold using the limit order
    ✓ Execute multiple transactions to fill orders in one block with the circuit breaker triggered
    ✓ Fill an order in different blocks after the circuit breaker has been triggered
    ✓ Fill an order in the same block after the circuit breaker has been triggered
    ✓ Fail to place a second market order in the same block due to no filled amount
    ✓ Fail to place a second limit order in the same block due to over the circuit breaker threshold
    ✓ Fill an order within the circuit breaker minimum rage
    ✓ Fill an order outside the circuit breaker minimum rage
    ✓ Fill an order within the circuit breaker that has reached max unit price
  Unwind positions
    ✓ Unwind a position partially until the circuit breaker threshold
    ✓ Unwind no position due to circuit breaker

LendingMarket - Initialization
  ✓ Deploy Lending Market
  ✓ Create an order book
  ✓ Fail to deploy Lending Market with circuit breaker range more than equal to 10000
  ✓ Fail to create an order book due to invalid caller

LendingMarket - Itayose
  ✓ Execute Itayose call(Case 1)
  ✓ Execute Itayose call(Case 2)
  ✓ Execute Itayose call(Case 3)
  ✓ Execute Itayose call(Case 4)
  ✓ Execute Itayose call(Case 5)
  ✓ Execute Itayose call(Case 6)
  ✓ Execute Itayose call(Case 7)
  ✓ Execute Itayose call(Case 8)
  ✓ Execute Itayose call without pre-orders
  ✓ Fail to create a pre-order due to an existing order with a past maturity
  ✓ Fail to create a pre-order due to not in the pre-order period
  ✓ Fail to cancel a pre-order due to in the Itayose period
  ✓ Fail to execute the Itayose call due to not in the Itayose period
  ✓ Fail to execute the Itayose call due to invalid caller

LendingMarket - Operations
  ✓ Pause and unpause the lending market
  ✓ Fail to update the order fee rate due to invalid caller
  ✓ Fail to update the circuit breaker limit range due to invalid caller
```

```
  LendingMarket - Orders
    Check the block unit price
      ✓ Check with a single order
      ✓ Check with multiple orders in the same block
      ✓ Check with multiple orders in the different block
      ✓ Check with 5 orders in the different block
      ✓ Check with over 5 orders in the different block
      ✓ Check with unwinding
      ✓ Check with an order less than the reliable amount
      ✓ Check with an order equal to the reliable amount
    Execute orders
      ✓ Fail to create a order due to the matured order book
      ✓ Fail to unwind the position due to the matured order book
      ✓ Fail to create an order due to invalid caller
      ✓ Fail to cancel the order due to invalid caller
      ✓ Fail to unwind the position due to invalid caller
      ✓ Fail to create a order due to an existing order with a past maturity
    Execute pre-orders
      ✓ Fail to create a lending pre-order due to opposite order existing
      ✓ Fail to create a borrowing pre-order due to opposite order existing
      ✓ Fail to create a pre-order due to invalid caller
    Clean up orders
      ✓ Clean up a lending order
      ✓ Clean up a borrowing order
      ✓ Fail to clean up orders due to invalid caller

  LendingMarketController - Calculations
    Total Funds Calculations
      ✓ Calculate total funds without positions
      ✓ Calculate total funds with positions
      ✓ Calculate total funds with additional lent amount exceeded deposit amount
    Order Estimations
      ✓ Get an borrowing order estimation from one lending order on the order book
      ✓ Get an lending order estimation from one borrowing order on the order book
      ✓ Get an order estimation from multiple order on the order book
      ✓ Get an order estimation blocked by the circuit breaker
      ✓ Get an borrowing order estimation on the empty order book
      ✓ Get an lending order estimation on the empty order book

  LendingMarketController - Itayose
    ✓ Get Itayose estimation with no pre-orders
    ✓ Execute Itayose call on the initial markets, the opening price become the same as the lending order
    ✓ Execute Itayose call on the initial markets, the opening price become the same as the borrowing
order
    ✓ Fill a borrowing pre-order whose unit price is lower than the opening price after Itayose call
    ✓ Fill a lending pre-order whose unit price is higher than the opening price after Itayose call.
    ✓ Execute Itayose call after auto-rolling
    ✓ Fill orders that are not filled with Itayose call and not the same as the opening unit price
    ✓ Fill orders that are not filled with Itayose call and the same as the opening unit price
    ✓ Filled pre-order should be returned as inactive orders with opening unit price
    ✓ Crete a pre-order with permit
    ✓ Fail to create an order due to too many orders
    ✓ Fail to create an pre-order due to invalid maturity
    ✓ Fail to create an pre-order and deposit token due to invalid maturity
    ✓ Fail to create an pre-order and deposit token with permit due to invalid maturity

  LendingMarketController - Liquidations
    External liquidator
      ✓ Fail to execute liquidation call due to non-operator
      ✓ Fail to execute liquidation call due to invalid maturity
      ✓ Fail to execute liquidation call due to non-collateral currency selected
      ✓ Fail to execute forced repayment due to non-operator
      ✓ Fail to execute forced repayment due to invalid maturity
      ✓ Fail to execute forced repayment due to non-collateral currency selected
      ✓ Fail to execute operations for collateral due to non lending market controller
      ✓ Fail to execute operations for debt due to non lending market controller
    Liquidations
      ✓ Liquidate less than 50% borrowing position in case the one position doesn't cover liquidation
amount
      ✓ Liquidate 50% borrowing position in case the one position cover liquidation amount
      ✓ Liquidate borrowing position using zero-coupon bonds
```

```
      ✓ Liquidate insolvent user using the reserve fund
      ✓ Liquidate insolvent user without using the reserve fund
      ✓ Liquidate borrowing position after auto-roll
      ✓ Fail to liquidate a borrowing position due to no debt
      ✓ Fail to liquidate a borrowing position due to no liquidation amount
      ✓ Fail to liquidate a borrowing position due to insufficient collateral
    Delisting
      ✓ Execute repayment & redemption
      ✓ Execute repayment & redemption after auto-roll
      ✓ Force repayment of overdue borrowing positions
      ✓ Force a insolvent user to repay in the first market
      ✓ Force a insolvent user to repay in the seconde market
      ✓ Force a insolvent user to repay after auto roll using 1000000 as a compound factor
      ✓ Force a insolvent user to repay after auto roll using 1000000000000000000 as a compound factor
      ✓ Force a insolvent user to repay after auto roll using 1000000000000000000000000000000000000000 as a
compound factor
      ✓ Fail to repay due to active market
      ✓ Fail to repay due to active currency
      ✓ Fail to redeem due to active market
      ✓ Fail to redeem due to under repayment period
      ✓ Fail to repay due to invalid maturity
      ✓ Fail to redeem due to invalid maturity

  LendingMarketController - Operations
    Operations
      Order books
        ✓ Get the lending market detail with empty order book
        ✓ Get the lending market detail with non-empty order book
        ✓ Get the multiple lending market details
      Pause/Unpause
        ✓ Pause lending markets
        ✓ Change the operator
      Protocol updates
        ✓ Get the min debt unit price
        ✓ Update the min debt unit price
        ✓ Get the current min debt unit price
        ✓ Update the order fee rate
        ✓ Update the circuit breaker limit range
        ✓ Update beacon proxy implementations and calculate Genesis value
        ✓ Fail to update the order fee rate due to execution by non-owner
        ✓ Fail to update the circuit breaker limit range due to execution by non-owner
        ✓ Fail to update the min debt unit price due to execution by non-owner
        ✓ Fail to update the min debt unit price due to invalid value
      Calculation
┌───────────────┬───────┬─────┬───────┬─────────────┬────────────────────┬──────────────────────┐
│    (index)    │ Alice │ Bob │ Carol │ ReserveFund │ TotalLendingSupply │ TotalBorrowingSupply │
├───────────────┼───────┼─────┼───────┼─────────────┼────────────────────┼──────────────────────┤
│ GenesisValue  │  '0'  │ '0' │  '0'  │     '0'     │        '0'         │         '0'          │
└───────────────┴───────┴─────┴───────┴─────────────┴────────────────────┴──────────────────────┘
┌───────────────┬──────────────────────────────┬────────────────────────────────┬───────┬──────────────────────────
───────┬────────────────────────────┬────────────────────────┐
│    (index)    │            Alice             │              Bob               │ Carol │         ReserveFund
│    TotalLendingSupply     │ TotalBorrowingSupply │
├───────────────┼──────────────────────────────┼────────────────────────────────┼───────┼──────────────────────────
───────┼────────────────────────────┼────────────────────────┤
│ GenesisValue │ '1250000000000000000000000' │ '-1259380451830791474314283O' │  '0'  │
'311641853754439000000O' │ '311641853754439000000O' │         '0'          │
└───────────────┴──────────────────────────────┴────────────────────────────────┴───────┴──────────────────────────
───────┴────────────────────────────┴────────────────────────┘
┌───────────────┬──────────────────────────────┬────────────────────────────────┬───────┬──────────────────────────
───────┬───────────────────────────────┬───────────────────────────────┐
│    (index)    │            Alice             │              Bob               │ Carol │         ReserveFund
│      TotalLendingSupply       │      TotalBorrowingSupply      │
├───────────────┼──────────────────────────────┼────────────────────────────────┼───────┼──────────────────────────
───────┼───────────────────────────────┼───────────────────────────────┤
│ GenesisValue │ '1250000000000000000000000' │ '-1259380451830791474314283O' │  '0'  │
'938045183079147431428 30' │ '1259380451830791474314283O' │ '1259380451830791474314283O' │
└───────────────┴──────────────────────────────┴────────────────────────────────┴───────┴──────────────────────────
───────┴───────────────────────────────┴───────────────────────────────┘
┌───────────────┬──────────────────────────────┬────────────────────────────────┬───────┬──────────────────────────
───────┬───────────────────────────────┬───────────────────────────────┐
│    (index)    │            Alice             │              Bob               │ Carol │         ReserveFund
```

```
|      TotalLendingSupply      |     TotalBorrowingSupply     |
|──────────────┼──────────────────────────────┼──────────────────────────────┼───────┼──────────────────
──────┼──────────────────────────────┼──────────────────────────────┤
| GenesisValue | '1250000000000000000000000' | '-125938045183079147431428 30' |  '0'  |
'938045183079147431428 30' | '125938045183079147431428 30' | '125938045183079147431428 30' |
└──────────────┴──────────────────────────────┴──────────────────────────────┴───────┴──────────────────
──────┴──────────────────────────────┴──────────────────────────────┘

┌──────────────┬──────────────────────────────┬──────────────────────────────┬───────┬──────────────────
──────┬──────────────────────────────┬──────────────────────────────┐
|   (index)    |            Alice             |              Bob             | Carol |        ReserveFund
|      TotalLendingSupply      |     TotalBorrowingSupply     |
|──────────────┼──────────────────────────────┼──────────────────────────────┼───────┼──────────────────
──────┼──────────────────────────────┼──────────────────────────────┤
| GenesisValue | '1250000000000000000000000' | '-126567579754842184087485 11' |  '0'  |
'938045183079147431428 30' | '125938045183079147431428 30' | '125938045183079147431428 30' |
└──────────────┴──────────────────────────────┴──────────────────────────────┴───────┴──────────────────
──────┴──────────────────────────────┴──────────────────────────────┘

┌──────────────┬──────────────────────────────┬──────────────────────────────┬───────┬──────────────────
──────┬──────────────────────────────┬──────────────────────────────┐
|   (index)    |            Alice             |              Bob             | Carol |        ReserveFund
|      TotalLendingSupply      |     TotalBorrowingSupply     |
|──────────────┼──────────────────────────────┼──────────────────────────────┼───────┼──────────────────
──────┼──────────────────────────────┼──────────────────────────────┤
| GenesisValue | '1250000000000000000000000' | '-127200261221385656143159 39' |  '0'  |
'220026122138565614315939' | '127200261221385656143159 39' | '127200261221385656143159 39' |
└──────────────┴──────────────────────────────┴──────────────────────────────┴───────┴──────────────────
──────┴──────────────────────────────┴──────────────────────────────┘

┌──────────────┬──────────────────────────────┬──────────────────────────────┬───────┬──────────────────
──────┬──────────────────────────────┬──────────────────────────────┐
|   (index)    |            Alice             |              Bob             | Carol |        ReserveFund
|      TotalLendingSupply      |     TotalBorrowingSupply     |
|──────────────┼──────────────────────────────┼──────────────────────────────┼───────┼──────────────────
──────┼──────────────────────────────┼──────────────────────────────┤
| GenesisValue | '1250000000000000000000000' | '-127200261221385656143159 39' |  '0'  |
'220026122138565614315939' | '127200261221385656143159 39' | '127200261221385656143159 39' |
└──────────────┴──────────────────────────────┴──────────────────────────────┴───────┴──────────────────
──────┴──────────────────────────────┴──────────────────────────────┘
```

✓ Calculate the genesis value per maturity
✓ Calculate the total funds from inactive lending order list
✓ Calculate the total funds from inactive borrowing order list
✓ Calculate the total funds with open orders less than min debt unit price
✓ Calculate the total funds with position less than min debt unit price

LendingMarketController - Orders
Initialization
✓ Initialize the lending market
✓ Fail to initialize the lending market due to invalid currency
✓ Fail to initialize the lending market due to execution by non-owner
✓ Fail to initialize the lending market due to too many token decimals
✓ Get genesisDate
✓ Get beacon proxy implementations
✓ Fail to get beacon proxy implementations
✓ Create a order book

(index)	Maturity	Maturity(Unixtime)
0	'September 25, 2285 12:00 AM'	'9963561600'
1	'December 25, 2285 12:00 AM'	'9971424000'
2	'March 26, 2286 12:00 AM'	'9979286400'
3	'June 25, 2286 12:00 AM'	'9987148800'
4	'September 24, 2286 12:00 AM'	'9995011200'
5	'December 31, 2286 12:00 AM'	'10003478400'
6	'March 25, 2287 12:00 AM'	'10010736000'
7	'June 24, 2287 12:00 AM'	'10018598400'
8	'September 30, 2287 12:00 AM'	'10027065600'

✓ Create multiple lending markets
✓ Fail to create a order book because market is not initialized
✓ Fail to create a order book because currency does not exist
✓ Fail to create a order book due to invalid pre-opening date
✓ Fail to create a order book due to execution by non-owner
Orders

✓ Get a market currency data
✓ Add orders and check rates

(index)	Alice	Bob	Carol	ReserveFund
TotalPresentValue	'100000000000000000'	'0'	'-100249310977929985'	'249310977929985'
FutureValue(9963561600)	'114678899082568807'	'0'	'-114964806167350900'	'285907084782093'
FutureValue(9971424000)	'0'	'0'	'0'	'0'
GenesisValue	'0'	'0'	'0'	'0'

(index)	Alice	Bob	Carol	ReserveFund
TotalPresentValue	'140000000000000000'	'-40099726002029427'	'-100249310977929985'	'349036979959412'
FutureValue(9963561600)	'114678899082568807'	'0'	'-114964806167350900'	'285907084782093'
FutureValue(9971424000)	'45871559633027523'	'-45985924314253930'	'0'	'114364681226407'
GenesisValue	'0'	'0'	'0'	'0'

(index)	Alice	Bob	Carol	ReserveFund
TotalPresentValue	'154442736772314282'	'-40099726002029427'	'-115227928355188252'	'385044308246323'
FutureValue(9963561600)	'0'	'0'	'0'	'0'
FutureValue(9971424000)	'177113230243479681'	'-45985924314253930'	'-132142119673381023'	'441564573676976'
GenesisValue	'11467889908256880700000000'	'0'	'-11546571097498302283956248'	'28590708478209300000000'

(index)	Alice	Bob	Carol	ReserveFund
TotalPresentValue	'154442736772314282'	'-40099726002029427'	'-115227928355188252'	'385044308246323'
FutureValue(9963561600)	'0'	'0'	'0'	'0'
FutureValue(9971424000)	'177113230243479681'	'-45985924314253930'	'-132142119673381023'	'441564573676976'
GenesisValue	'11467889908256880700000000'	'0'	'-11546571097498302283956248'	'28590708478209300000000'

(index)	Alice	Bob	Carol	ReserveFund
TotalPresentValue	'154442736772314282'	'-40099726002029427'	'-115227928355188252'	'884917584903398'
FutureValue(9963561600)	'0'	'0'	'0'	'0'
FutureValue(9971424000)	'177113230243479681'	'-45985924314253930'	'-132142119673381023'	'1014813744155273'
GenesisValue	'11467889908256880700000000'	'0'	'-11546571097498302283956248'	'78681189241421583956248'

(index)	Alice	Bob	Carol	ReserveFund
TotalPresentValue	'154442736772314282'	'-40099726002029427'	'-115227928355188252'	'884917584903398'
FutureValue(9963561600)	'0'	'0'	'0'	'0'
FutureValue(9971424000)	'177113230243479681'	'-45985924314253930'	'-132142119673381023'	'1014813744155273'
GenesisValue	'1146788990825688070000000'	'0'	'-11546571097498302283956248'	'78681189241421583956248'

- ✓ Add orders and rotate markets
- ✓ Deposit and add an order
- ✓ Deposit and add an order(payable)
- ✓ Add multiple orders using multicall
- ✓ Get an order
- ✓ Cancel an order
- ✓ Get an active order from one market
- ✓ Get active orders from multiple markets
- ✓ Get active orders from multiple currencies
- ✓ Get active orders and inactive orders
- ✓ Get an empty order list
- ✓ Get an active position from one market
- ✓ Get active positions of a user who has both side position
- ✓ Get active positions from multiple markets
- ✓ Get active positions from multiple currencies
- ✓ Get an active position after auto-rolls
- ✓ Get an empty position list of a user who has an open order
- ✓ Get an empty position list of a user who has no open order

(index)	Total	Market0	Market1	Market2
PresentValue(Alice)	'-50000000000000000'	'-50000000000000000'	'0'	'0'

(index)	Total	Market0	Market1	Market2
PresentValue(Alice)	'-100000000000000000'	'-50000000000000000'	'-50000000000000000'	'0'

(index)	Total	Market0	Market1	Market2
PresentValue(Alice)	'-20000000000000000'	'-50000000000000000'	'-50000000000000000'	'80000000000000000'

- ✓ Fill lending orders and check the total present value
- ✓ Calculate the funds of users who have a large lending position and a small borrowing position
- ✓ Calculate the funds of users who have a small lending position and a large borrowing position
- ✓ Fill lending orders and partially fill own order.
- ✓ Fill lending orders including own order
- ✓ Fill borrowing orders including own order
- ✓ Fill lending orders including another user's order for unwinding
- ✓ Fill multiple lending orders without partially filled orders

Limit Order

- ✓ Fill all lending orders at one rate
- ✓ Fill all borrowing orders at one rate
- ✓ Fill orders partially at one rate
- ✓ Fill orders at one rate with a partial amount with limit rate
- ✓ Fill orders at one rate with a over amount with limit rate
- ✓ Fill an own order
- ✓ Fill multiple lending order at different rates with limit rate

```
        ✓ Fill multiple borrowing order at different rates with limit rate
        ✓ Fill multiple lending order at different rates with limit rate
        ✓ Fill multiple borrowing order at different rates with limit rate
        ✓ Fill an order partially out of the orders held
        ✓ Fill multiple orders partially out of the orders held
        ✓ Fill 100 orders in same rate
        ✓ Fill 100 orders in different rate
        ✓ Deposit and place a lending order with permit
      Market Order
        ✓ Fail to place a borrow market order
        ✓ Fail to place a lend market order
      Unwinding
        ✓ Unwind a lending order
        ✓ Unwind a borrowing order
        ✓ Unwind a order at the order book that don't has enough orders
        ✓ Unwind a order ta the order book that don't has any orders
        ✓ Fail to execute unwinding due to insufficient collateral
        ✓ Fail to execute unwinding due to no future values user has
        ✓ Fail to execute unwinding due to invalid maturity
      Order Book
        ✓ Get all borrow orders
        ✓ Get all lend orders
        ✓ Get all borrow orders in multiple calls
        ✓ Get all lend orders in multiple calls
        ✓ Get borrow orders starting from a non-existent unit price
        ✓ Get lend orders starting from a non-existent unit price
        ✓ Get borrow orders starting from the minimum unit price
        ✓ Get borrow orders starting from the maximum unit price
      Failure
        ✓ Fail to create an order due to insufficient collateral
        ✓ Fail to create an order due to too many orders
        ✓ Fail to create an order due to invalid maturity
        ✓ Fail to create an order and deposit token due to invalid maturity
        ✓ Fail to create an order and deposit token with permit due to invalid maturity
        ✓ Fail to cancel an order due to invalid maturity
        ✓ Fail to rotate lending markets due to pre-maturity
        ✓ Fail to cancel an order due to execution by non-maker
        ✓ Fail to cancel an order due to invalid order

  LendingMarketController - Rotations
    General order books
      ✓ Rotate markets multiple times under condition without lending position
┌──────────────────────────┬──────────────────────────────────┬──────────────────────────────────┐
│          (index)         │              Alice               │               Bob                │
├──────────────────────────┼──────────────────────────────────┼──────────────────────────────────┤
│ GenesisValue(10027065600) │ '125000000000000000000000000' │ '-125841709644168599335426 24' │
│ GenesisValue(10034928000) │ '-19225179923187053587525 99' │  '176012490957108509759 2713'  │
│ GenesisValue(10042790400) │ '14703632488793737634137799' │ '-15057240053258799070042501' │
│ GenesisValue(10050652800) │ '-46545465373652190633572 01' │  '40875103903848847647907 24'  │
└──────────────────────────┴──────────────────────────────────┴──────────────────────────────────┘
      ✓ Rotate markets multiple times under condition where users have lending positions that are offset
after the auto-rolls every time
      ✓ Rotate markets using the unit price average(only one order) during the observation period
      ✓ Rotate markets using the unit price average(multiple orders) during the observation period
      ✓ Rotate markets using the estimated auto-roll price
      ✓ Rotate markets using the past auto-roll price as an order is filled on dates too old
      ✓ Rotate markets using the past auto-roll price as no orders are filled
      ✓ Rotate markets including one market that has orders adjusted by with the residual amount.
      ✓ Fail to rotate order books due to no currency
      ✓ Fail to rotate order books due to no order book
      ✓ Fail to rotate order books due to no zc token
    Pre-open order books
      ✓ Rotate markets including one market that has pre-orders adjusted by with the residual amount.
      ✓ Rotate markets including one market that has pre-orders partially filled and  adjusted by with the
residual amount.

  LendingMarketController - Terminations
    Terminations
      ✓ Get the termination status
      ✓ Execute an emergency termination without an order and check all inactivated functions
      ✓ Execute an emergency termination with orders of single market
      ✓ Execute an emergency termination with orders of multiple markets
```

```
      ✓ Execute an emergency termination with orders after auto-rolls
      ✓ Execute an emergency termination with paused markets
      ✓ Fail to redeem due to a insolvent user
      ✓ Fail to redeem due to 2nd execution
      ✓ Fail to execute the emergency termination due to execution by non-owner
      ✓ Fail to initialize the lending market due to the market being already initialized
      ✓ Fail to execute the emergency settlement due to no markets terminated

  LendingMarketController - Tokenization
    Token Deployments
      ✓ Create a new zc perpetual token
      ✓ Create a new zc token with maturity
      ✓ Create a new zc token with maturity(+ 9 month)
      ✓ Create a new zc token manually
      ✓ Fail to migrate a lending market manually if it already exists
      ✓ Fail to migrate a lending market manually if the maturity is invalid
      ✓ Fail to migrate a lending market manually if the caller is not owner
      ✓ Fail to migrate a lending market manually due to too many token decimals
    Withdraw and Deposit
      ✓ Withdraw zc tokens without used collaterals
      ✓ Withdraw zc tokens used as discounted collateral
      ✓ Withdraw zc tokens used as discounted collateral and allocated collateral as is
      ✓ Withdraw all zc tokens used as discounted collateral and allocated collateral as is
      ✓ Withdraw zc perpetual tokens without allocated collaterals
      ✓ Withdraw zc perpetual tokens used as discounted collateral
      ✓ Withdraw zc perpetual tokens used as discounted collateral and allocated collateral as is
      ✓ Withdraw zc tokens partially
      ✓ Withdraw zc perpetual tokens partially
      ✓ Deposit zc tokens
      ✓ Deposit zc tokens with exceeded amount
      ✓ Deposit zc perpetual tokens
      ✓ Deposit zc perpetual tokens with exceeded amount
      ✓ Fail to withdraw zc tokens if the maturity is invalid
      ✓ Fail to deposit zc tokens if the maturity is invalid
      ✓ Fail to withdraw zc tokens if the caller has no balance of zc tokens
      ✓ Fail to deposit zc tokens if the caller has no balance of zc tokens
      ✓ Fail to withdraw zc tokens if the caller has no balance of zc perpetual tokens
      ✓ Fail to deposit zc tokens if the caller has no balance of zc perpetual tokens

  LendingMarketOperationLogic
    Testing calculateNextMaturity()
      ✓ Get the last Friday after 3 months
      ✓ Get the date 1 week later

  OrderStatisticsTree - drop values
    Dropping
      Lending market orders
        Drop nodes from the tree by one action
          1 nodes in the tree
            ✓ Fill 1 node partially: Target amount is 50000000
            ✓ Drop all nodes: Target amount is 100000000
            ✓ Drop all nodes using an exceeding amount: Target amount is 1000000000
          2 nodes in the tree
            ✓ Fill 1 node partially: Target amount is 100000000
            ✓ Drop 1 node: Target amount is 300000000
            ✓ Drop 1 node, Fill 1 node partially: Target amount is 350000000
            ✓ Drop all nodes: Target amount is 400000000
            ✓ Drop all nodes using an exceeding amount: Target amount is 1000000000
          3 nodes in the tree
            ✓ Fill 1 node partially: Target amount is 300000000
            ✓ Drop 1 node: Target amount is 500000000
            ✓ Drop 1 node, Fill 1 node partially: Target amount is 600000000
            ✓ Drop 2 nodes: Target amount is 800000000
            ✓ Drop all nodes: Target amount is 900000000
            ✓ Drop all nodes using an exceeding amount: Target amount is 1000000000
          3 nodes with multiple orders in the tree
            ✓ Fill 1 node partially, Remove 4 order with a unfilled amount: Target amount is 350000000
            ✓ Fill 1 node partially, Remove 4 order without a unfilled amount: Target amount is 400000000
            ✓ Drop 1 node: Target amount is 500000000
            ✓ Drop 1 node, Fill 1 node partially: Target amount is 580000000
            ✓ Drop 1 node, Fill 1 node partially, Remove 2 order with a unfilled amount: Target amount is
620000000
```

```
            ✓ Drop 1 node, Fill 1 node partially, Remove 2 order without a unfilled amount: Target amount
is 700000000
            ✓ Drop 2 nodes: Target amount is 800000000
            ✓ Drop 2 nodes, Fill 1 node partially: Target amount is 820000000
            ✓ Drop 2 nodes, Fill 1 node partially, Remove 1 order with a unfilled amount: Target amount is
830000000
            ✓ Drop 2 nodes, Fill 1 node partially, Remove 1 order without a unfilled amount: Target amount
is 850000000
            ✓ Drop all nodes: Target amount is 900000000
            ✓ Drop all nodes using an exceeding amount: Target amount is 1000000000
          Many nodes in the tree
            ✓ Fill 1 node partially: Target amount is 50000000
            ✓ Drop 1 node: Target amount is 100000000
            ✓ Drop multiple nodes less than the root: Target amount is 400000000
            ✓ Drop multiple nodes less than the root, Fill root node partially: Target amount is
6000000000
            ✓ Drop multiple nodes less than or equal to the root: Target amount is 6600000000
            ✓ Drop multiple nodes across the root: Target amount is 7000000000
            ✓ Drop all nodes: Target amount is 7500000000
            ✓ Drop all nodes using an exceeding amount: Target amount is 10000000000
        Drop nodes from the tree by multiple actions
          1 nodes in the tree
            ✓ Fill 1 node partially: Target amount is 50000000
            ✓ Drop all nodes: Target amount is 100000000
            ✓ Drop all nodes using an exceeding amount: Target amount is 1000000000
          2 nodes in the tree
            ✓ Fill 1 node partially: Target amount is 100000000
            ✓ Drop 1 node: Target amount is 300000000
            ✓ Drop 1 node, Fill 1 node partially: Target amount is 350000000
            ✓ Drop all nodes: Target amount is 400000000
            ✓ Drop all nodes using an exceeding amount: Target amount is 1000000000
          3 nodes in the tree
            ✓ Fill 1 node partially: Target amount is 300000000
            ✓ Drop 1 node: Target amount is 500000000
            ✓ Drop 1 node, Fill 1 node partially: Target amount is 600000000
            ✓ Drop 2 nodes: Target amount is 800000000
            ✓ Drop all nodes: Target amount is 900000000
            ✓ Drop all nodes using an exceeding amount: Target amount is 1000000000
          3 nodes with multiple orders in the tree
            ✓ Fill 1 node partially, Remove 4 order with a unfilled amount: Target amount is 350000000
            ✓ Fill 1 node partially, Remove 4 order without a unfilled amount: Target amount is 400000000
            ✓ Drop 1 node: Target amount is 500000000
            ✓ Drop 1 node, Fill 1 node partially: Target amount is 580000000
            ✓ Drop 1 node, Fill 1 node partially, Remove 2 order with a unfilled amount: Target amount is
620000000
            ✓ Drop 1 node, Fill 1 node partially, Remove 2 order without a unfilled amount: Target amount
is 700000000
            ✓ Drop 2 nodes: Target amount is 800000000
            ✓ Drop 2 nodes, Fill 1 node partially: Target amount is 820000000
            ✓ Drop 2 nodes, Fill 1 node partially, Remove 1 order with a unfilled amount: Target amount is
830000000
            ✓ Drop 2 nodes, Fill 1 node partially, Remove 1 order without a unfilled amount: Target amount
is 850000000
            ✓ Drop all nodes: Target amount is 900000000
            ✓ Drop all nodes using an exceeding amount: Target amount is 1000000000
          Many nodes in the tree
            ✓ Fill 1 node partially: Target amount is 50000000
            ✓ Drop 1 node: Target amount is 100000000
            ✓ Drop multiple nodes less than the root: Target amount is 400000000
            ✓ Drop multiple nodes less than the root, Fill root node partially: Target amount is
6000000000
            ✓ Drop multiple nodes less than or equal to the root: Target amount is 6600000000
            ✓ Drop multiple nodes across the root: Target amount is 7000000000
            ✓ Drop all nodes: Target amount is 7500000000
            ✓ Drop all nodes using an exceeding amount: Target amount is 10000000000
        Drop nodes from the tree by repeated inserting and dropping
          1 nodes in the tree
            ✓ Fill 1 node partially: Target amount is 50000000
            ✓ Drop all nodes: Target amount is 100000000
            ✓ Drop all nodes using an exceeding amount: Target amount is 1000000000
          2 nodes in the tree
            ✓ Fill 1 node partially: Target amount is 100000000
```

```
            ✓ Drop 1 node: Target amount is 300000000
            ✓ Drop 1 node, Fill 1 node partially: Target amount is 350000000
            ✓ Drop all nodes: Target amount is 400000000
            ✓ Drop all nodes using an exceeding amount: Target amount is 1000000000
          3 nodes in the tree
            ✓ Fill 1 node partially: Target amount is 300000000
            ✓ Drop 1 node: Target amount is 500000000
            ✓ Drop 1 node, Fill 1 node partially: Target amount is 600000000
            ✓ Drop 2 nodes: Target amount is 800000000
            ✓ Drop all nodes: Target amount is 900000000
            ✓ Drop all nodes using an exceeding amount: Target amount is 1000000000
          3 nodes with multiple orders in the tree
            ✓ Fill 1 node partially, Remove 4 order with a unfilled amount: Target amount is 350000000
            ✓ Fill 1 node partially, Remove 4 order without a unfilled amount: Target amount is 400000000
            ✓ Drop 1 node: Target amount is 500000000
            ✓ Drop 1 node, Fill 1 node partially: Target amount is 580000000
            ✓ Drop 1 node, Fill 1 node partially, Remove 2 order with a unfilled amount: Target amount is
620000000
            ✓ Drop 1 node, Fill 1 node partially, Remove 2 order without a unfilled amount: Target amount
is 700000000
            ✓ Drop 2 nodes: Target amount is 800000000
            ✓ Drop 2 nodes, Fill 1 node partially: Target amount is 820000000
            ✓ Drop 2 nodes, Fill 1 node partially, Remove 1 order with a unfilled amount: Target amount is
830000000
            ✓ Drop 2 nodes, Fill 1 node partially, Remove 1 order without a unfilled amount: Target amount
is 850000000
            ✓ Drop all nodes: Target amount is 900000000
            ✓ Drop all nodes using an exceeding amount: Target amount is 1000000000
          Many nodes in the tree
            ✓ Fill 1 node partially: Target amount is 50000000
            ✓ Drop 1 node: Target amount is 100000000
            ✓ Drop multiple nodes less than the root: Target amount is 400000000
            ✓ Drop multiple nodes less than the root, Fill root node partially: Target amount is
6000000000
            ✓ Drop multiple nodes less than or equal to the root: Target amount is 6600000000
            ✓ Drop multiple nodes across the root: Target amount is 7000000000
            ✓ Drop all nodes: Target amount is 7500000000
            ✓ Drop all nodes using an exceeding amount: Target amount is 10000000000
      Lending limit orders
        Drop nodes from the tree
          1 nodes in the tree
            ✓ Drop all nodes: Target amount is 100000000, Limit value 9800
            ✓ Drop all nodes by limitValue: Target amount is 200000000, Limit value 9800
          2 nodes in the tree
            ✓ Drop 1 node: Target amount is 300000000, Limit value 9801
            ✓ Drop 1 node by limitValue: Target amount is 350000000, Limit value 9801
            ✓ Drop 1 node, Fill 1 node partially: Target amount is 350000000, Limit value 9800
            ✓ Drop all nodes: Target amount is 400000000, Limit value 9800
            ✓ Drop all nodes by limitValue: Target amount is 1000000000, Limit value 9800
          3 nodes in the tree
            ✓ Drop 1 node: Target amount is 500000000, Limit value 9802
            ✓ Drop 1 node by limitValue: Target amount is 600000000, Limit value 9802
            ✓ Drop 1 node, Fill 1 node partially: Target amount is 600000000, Limit value 9801
            ✓ Drop 2 nodes: Target amount is 800000000, Limit value 9801
            ✓ Drop 2 nodes by limitValue: Target amount is 900000000, Limit value 9801
            ✓ Drop all nodes: Target amount is 900000000, Limit value 9800
            ✓ Drop all nodes by limitValue: Target amount is 1000000000, Limit value 9800
          3 discontinuous nodes in the tree
            ✓ Drop 1 node: Target amount is 1000000000, Limit value 9803
            ✓ Drop 1 node, Fill 1 node partially: Target amount is 700000000, Limit value 9801
            ✓ Drop 2 node: Target amount is 1000000000, Limit value 9801
            ✓ Drop all nodes: Target amount is 1000000000, Limit value 9799
      Lending unwind orders
        Drop nodes from the tree
          1 nodes in the tree
            ✓ Fill 1 node partially: Unwind future value 125000000
            ✓ Drop all nodes: Unwind future value 250000000
            ✓ Drop all nodes without limits and amounts: Unwind future value 0
            ✓ Drop all nodes by an exceeding amount: Unwind future value 300000000
          2 nodes in the tree
            ✓ Fill 1 node partially: Unwind future value 125000000
            ✓ Drop 1 node: Unwind future value 250000000
```

```
            ✓ Drop 1 node, Fill 1 node partially: Unwind future value 350000000
            ✓ Drop all nodes: Unwind future value 1250000000
            ✓ Drop all nodes without limits and amounts: Unwind future value 0
            ✓ Drop all nodes by an exceeding amount: Unwind future value 2000000000
          3 nodes in the tree
            ✓ Fill 1 node partially: Unwind future value 125000000
            ✓ Drop 1 node: Unwind future value 250000000
            ✓ Drop 1 node, Fill 1 node partially: Unwind future value 350000000
            ✓ Drop 2 nodes: Unwind future value 1250000000
            ✓ Drop 2 nodes, Fill 1 node partially: Unwind future value 1350000000
            ✓ Drop all nodes: Unwind future value 2250000000
            ✓ Drop all nodes without limits and amounts: Unwind future value 0
            ✓ Drop all nodes by an exceeding amount: Unwind future value 3000000000
      Borrowing market orders
        Drop nodes from the tree by one action
          1 nodes in the tree
            ✓ Fill 1 node partially: Target amount is 50000000
            ✓ Drop all nodes: Target amount is 100000000
            ✓ Drop all nodes using an exceeding amount: Target amount is 1000000000
          2 nodes in the tree
            ✓ Fill 1 node partially: Target amount is 50000000
            ✓ Drop 1 node: Target amount is 100000000
            ✓ Drop 1 node, Fill 1 node partially: Target amount is 200000000
            ✓ Drop all nodes: Target amount is 400000000
            ✓ Drop all nodes using an exceeding amount: Target amount is 1000000000
          3 nodes in the tree
            ✓ Fill 1 node partially: Target amount is 50000000
            ✓ Drop 1 node: Target amount is 100000000
            ✓ Drop 1 node, Fill 1 node partially: Target amount is 200000000
            ✓ Drop 2 nodes: Target amount is 400000000
            ✓ Drop all nodes: Target amount is 900000000
            ✓ Drop all nodes using an exceeding amount: Target amount is 1000000000
          3 nodes with multiple orders in the tree
            ✓ Fill 1 node partially, Remove 1 order with a unfilled amount: Target amount is 25000000
            ✓ Fill 1 node partially, Remove 1 order without a unfilled amount: Target amount is 50000000
            ✓ Drop 1 node: Target amount is 100000000
            ✓ Drop 1 node, Fill 1 node partially: Target amount is 150000000
            ✓ Drop 1 node, Fill 1 node partially, Remove 2 order with a unfilled amount: Target amount is
280000000
            ✓ Drop 1 node, Fill 1 node partially, Remove 2 order without a unfilled amount: Target amount
is 300000000
            ✓ Drop 2 nodes: Target amount is 400000000
            ✓ Drop 2 nodes, Fill 1 node partially: Target amount is 450000000
            ✓ Drop 2 nodes, Fill 1 node partially, Remove 3 order with a unfilled amount: Target amount is
650000000
            ✓ Drop 2 nodes, Fill 1 node partially, Remove 3 order without a unfilled amount: Target amount
is 700000000
            ✓ Drop all nodes: Target amount is 900000000
            ✓ Drop all nodes using an exceeding amount: Target amount is 1000000000
          Many nodes in the tree
            ✓ Fill 1 node partially: Target amount is 50000000
            ✓ Drop 1 node: Target amount is 100000000
            ✓ Drop multiple nodes less than the root: Target amount is 400000000
            ✓ Drop multiple nodes less than the root, Fill root node partially: Target amount is
1300000000
            ✓ Drop multiple nodes less than or equal to the root: Target amount is 1600000000
            ✓ Drop multiple nodes across the root: Target amount is 3000000000
            ✓ Drop all nodes: Target amount is 7500000000
            ✓ Drop all nodes using an exceeding amount: Target amount is 10000000000
        Drop nodes from the tree by multiple actions
          1 nodes in the tree
            ✓ Fill 1 node partially: Target amount is 50000000
            ✓ Drop all nodes: Target amount is 100000000
            ✓ Drop all nodes using an exceeding amount: Target amount is 1000000000
          2 nodes in the tree
            ✓ Fill 1 node partially: Target amount is 50000000
            ✓ Drop 1 node: Target amount is 100000000
            ✓ Drop 1 node, Fill 1 node partially: Target amount is 200000000
            ✓ Drop all nodes: Target amount is 400000000
            ✓ Drop all nodes using an exceeding amount: Target amount is 1000000000
          3 nodes in the tree
            ✓ Fill 1 node partially: Target amount is 50000000
```

```
            ✓ Drop 1 node: Target amount is 100000000
            ✓ Drop 1 node, Fill 1 node partially: Target amount is 200000000
            ✓ Drop 2 nodes: Target amount is 400000000
            ✓ Drop all nodes: Target amount is 900000000
            ✓ Drop all nodes using an exceeding amount: Target amount is 1000000000
          3 nodes with multiple orders in the tree
            ✓ Fill 1 node partially, Remove 1 order with a unfilled amount: Target amount is 25000000
            ✓ Fill 1 node partially, Remove 1 order without a unfilled amount: Target amount is 50000000
            ✓ Drop 1 node: Target amount is 100000000
            ✓ Drop 1 node, Fill 1 node partially: Target amount is 150000000
            ✓ Drop 1 node, Fill 1 node partially, Remove 2 order with a unfilled amount: Target amount is
280000000
            ✓ Drop 1 node, Fill 1 node partially, Remove 2 order without a unfilled amount: Target amount
is 300000000
            ✓ Drop 2 nodes: Target amount is 400000000
            ✓ Drop 2 nodes, Fill 1 node partially: Target amount is 450000000
            ✓ Drop 2 nodes, Fill 1 node partially, Remove 3 order with a unfilled amount: Target amount is
650000000
            ✓ Drop 2 nodes, Fill 1 node partially, Remove 3 order without a unfilled amount: Target amount
is 700000000
            ✓ Drop all nodes: Target amount is 900000000
            ✓ Drop all nodes using an exceeding amount: Target amount is 1000000000
          Many nodes in the tree
            ✓ Fill 1 node partially: Target amount is 50000000
            ✓ Drop 1 node: Target amount is 100000000
            ✓ Drop multiple nodes less than the root: Target amount is 400000000
            ✓ Drop multiple nodes less than the root, Fill root node partially: Target amount is
1300000000
            ✓ Drop multiple nodes less than or equal to the root: Target amount is 1600000000
            ✓ Drop multiple nodes across the root: Target amount is 3000000000
            ✓ Drop all nodes: Target amount is 7500000000
            ✓ Drop all nodes using an exceeding amount: Target amount is 10000000000
        Drop nodes from the tree by repeated inserting and dropping
          1 nodes in the tree
            ✓ Fill 1 node partially: Target amount is 50000000
            ✓ Drop all nodes: Target amount is 100000000
            ✓ Drop all nodes using an exceeding amount: Target amount is 1000000000
          2 nodes in the tree
            ✓ Fill 1 node partially: Target amount is 50000000
            ✓ Drop 1 node: Target amount is 100000000
            ✓ Drop 1 node, Fill 1 node partially: Target amount is 200000000
            ✓ Drop all nodes: Target amount is 400000000
            ✓ Drop all nodes using an exceeding amount: Target amount is 1000000000
          3 nodes in the tree
            ✓ Fill 1 node partially: Target amount is 50000000
            ✓ Drop 1 node: Target amount is 100000000
            ✓ Drop 1 node, Fill 1 node partially: Target amount is 200000000
            ✓ Drop 2 nodes: Target amount is 400000000
            ✓ Drop all nodes: Target amount is 900000000
            ✓ Drop all nodes using an exceeding amount: Target amount is 1000000000
          3 nodes with multiple orders in the tree
            ✓ Fill 1 node partially, Remove 1 order with a unfilled amount: Target amount is 25000000
            ✓ Fill 1 node partially, Remove 1 order without a unfilled amount: Target amount is 50000000
            ✓ Drop 1 node: Target amount is 100000000
            ✓ Drop 1 node, Fill 1 node partially: Target amount is 150000000
            ✓ Drop 1 node, Fill 1 node partially, Remove 2 order with a unfilled amount: Target amount is
280000000
            ✓ Drop 1 node, Fill 1 node partially, Remove 2 order without a unfilled amount: Target amount
is 300000000
            ✓ Drop 2 nodes: Target amount is 400000000
            ✓ Drop 2 nodes, Fill 1 node partially: Target amount is 450000000
            ✓ Drop 2 nodes, Fill 1 node partially, Remove 3 order with a unfilled amount: Target amount is
650000000
            ✓ Drop 2 nodes, Fill 1 node partially, Remove 3 order without a unfilled amount: Target amount
is 700000000
            ✓ Drop all nodes: Target amount is 900000000
            ✓ Drop all nodes using an exceeding amount: Target amount is 1000000000
          Many nodes in the tree
            ✓ Fill 1 node partially: Target amount is 50000000
            ✓ Drop 1 node: Target amount is 100000000
            ✓ Drop multiple nodes less than the root: Target amount is 400000000
            ✓ Drop multiple nodes less than the root, Fill root node partially: Target amount is
```

```
1300000000
            ✓ Drop multiple nodes less than or equal to the root: Target amount is 1600000000
            ✓ Drop multiple nodes across the root: Target amount is 3000000000
            ✓ Drop all nodes: Target amount is 7500000000
            ✓ Drop all nodes using an exceeding amount: Target amount is 10000000000
      Borrowing limit orders
        Drop nodes from the tree
          1 nodes in the tree
            ✓ Drop all nodes: Target amount is 100000000, Limit value 9800
            ✓ Drop all nodes by limitValue: Target amount is 200000000, Limit value 9800
          2 nodes in the tree
            ✓ Drop 1 node: Target amount is 100000000, Limit value 9800
            ✓ Drop 1 node by limitValue: Target amount is 200000000, Limit value 9800
            ✓ Drop 1 node, Fill 1 node partially: Target amount is 200000000, Limit value 9801
            ✓ Drop all nodes: Target amount is 400000000, Limit value 9801
            ✓ Drop all nodes by limitValue: Target amount is 1000000000, Limit value 9801
          3 nodes in the tree
            ✓ Drop 1 node: Target amount is 100000000, Limit value 9800
            ✓ Drop 1 node by limitValue: Target amount is 200000000, Limit value 9800
            ✓ Drop 1 node, Fill 1 node partially: Target amount is 200000000, Limit value 9801
            ✓ Drop 2 nodes: Target amount is 400000000, Limit value 9801
            ✓ Drop 2 nodes by limitValue: Target amount is 900000000, Limit value 9801
            ✓ Drop all nodes: Target amount is 900000000, Limit value 9802
            ✓ Drop all nodes by limitValue: Target amount is 1000000000, Limit value 9802
          3 discontinuous nodes in the tree
            ✓ Drop 1 node: Target amount is 1000000000, Limit value 9801
            ✓ Drop 1 node, Fill 1 node partially: Target amount is 200000000, Limit value 9803
            ✓ Drop 2 node: Target amount is 1000000000, Limit value 9803
            ✓ Drop all nodes: Target amount is 1000000000, Limit value 9805
      Borrowing unwind orders
        Drop nodes from the tree
          1 nodes in the tree
            ✓ Fill 1 node partially: Unwind future value 125000000
            ✓ Drop all nodes: Unwind future value 250000000
            ✓ Drop all nodes without limits and amounts: Unwind future value 0
            ✓ Drop all nodes by an exceeding amount: Unwind future value 300000000
          2 nodes in the tree
            ✓ Fill 1 node partially: Unwind future value 125000000
            ✓ Drop 1 node: Unwind future value 250000000
            ✓ Drop 1 node, Fill 1 node partially: Unwind future value 375000000
            ✓ Drop all nodes: Unwind future value 800000000
            ✓ Drop all nodes without limits and amounts: Unwind future value 0
            ✓ Drop all nodes by an exceeding amount: Unwind future value 1000000000
          3 nodes in the tree
            ✓ Fill 1 node partially: Unwind future value 125000000
            ✓ Drop 1 node: Unwind future value 250000000
            ✓ Drop 1 node, Fill 1 node partially: Unwind future value 375000000
            ✓ Drop 2 nodes: Unwind future value 800000000
            ✓ Drop 2 nodes, Fill 1 node partially: Unwind future value 1000000000
            ✓ Drop all nodes: Unwind future value 1200000000
            ✓ Drop all nodes without limits and amounts: Unwind future value 0
            ✓ Drop all nodes by an exceeding amount: Unwind future value 2000000000
      Drop and Insert
        ✓ Insert a lend order to the dropped node
        ✓ Insert a borrow order to the dropped node
    Estimation
      Estimate the dropped amount from the lending tree
        Estimate the dropped FV amount by PV amount
          ✓ Drop 1 node partially
          ✓ Drop 1 node
          ✓ Drop 1 node, Fill 1 node partially
          ✓ Drop 2 nodes, Fill 1 node partially
        Estimate the dropped PV amount by FV amount
          ✓ Drop 1 node partially
          ✓ Drop 1 node
          ✓ Drop 1 node, Fill 1 node partially
          ✓ Drop 2 nodes, Fill 1 node partially
      Estimate the dropped amount from the borrowing tree
        Estimate the dropped FV amount by PV amount
          ✓ Drop 1 node partially
          ✓ Drop 1 node
          ✓ Drop 1 node, Fill 1 node partially
```

```
          ✓ Drop 2 nodes, Fill 1 node partially
        Estimate the dropped PV amount by FV amount
          ✓ Drop 1 node partially
          ✓ Drop 1 node
          ✓ Drop 1 node, Fill 1 node partially
          ✓ Drop 2 nodes, Fill 1 node partially

  OrderStatisticsTree – insert and delete
Number of steps: 214
element, orderCount
  4827 0
  1299 0
  5193 0
  287 0
  7688 0
  5427 0
  2447 0
  9023 0
  4457 0
  9057 0
  7168 0
  9373 0
  1290 0
  6498 0
  7076 0
  2191 0
  1234 0
  3971 0
  1113 0
  7367 0
  4370 0
  4366 0
  1580 0
  7946 0
  2760 0
  4816 0
  5782 0
  7919 0
  7248 0
  4438 0
  6426 0
  8751 0
  9202 0
  4669 0
  4574 0
  6952 0
  8246 0
  9558 0
  2386 0
  4680 0
  4584 0
  4760 0
  4311 0
  4888 0
  5753 0
  544 0
  3471 0
  2915 0
  1760 0
  797 0
  4251 0
  7509 0
  5429 0
  1815 0
  8971 0
  4641 0
  412 0
  6180 0
  7897 0
  8118 0
  7940 0
  641 0
```

6497 0
3082 0
6918 0
1005 0
1105 0
9416 0
23 0
396 0
637 0
467 0
7096 0
8187 0
6517 0
6479 0
8779 0
3696 0
4116 0
2283 0
4817 0
1741 0
6465 0
2750 0
9414 0
1505 0
9757 0
627 0
969 0
500 0
3277 0
2316 0
8343 0
6151 0
7609 0
7603 0
8419 0
3148 0
8626 0
4042 0
246 0
6016 0
9136 0
5044 0
9843 0
8382 0
1715 0
4827 0
1299 0
5193 0
287 0
7688 0
5427 0
2447 0
9023 0
4457 0
9057 0
7168 0
9373 0
1290 0
6498 0
7076 0
2191 0
1234 0
3971 0
1113 0
7367 0
4370 0
4366 0
1580 0
7946 0
2760 0
4816 0
5782 0

```
7919 0
7248 0
4438 0
6426 0
8751 0
9202 0
4669 0
4574 0
6952 0
8246 0
9558 0
2386 0
4680 0
4584 0
4760 0
4311 0
4888 0
5753 0
544 0
3471 0
2915 0
1760 0
797 0
4251 0
7509 0
5429 0
1815 0
8971 0
4641 0
412 0
6180 0
7897 0
8118 0
7940 0
641 0
6497 0
3082 0
6918 0
1005 0
1105 0
9416 0
23 0
396 0
637 0
467 0
7096 0
8187 0
6517 0
6479 0
8779 0
3696 0
4116 0
2283 0
4817 0
1741 0
6465 0
2750 0
9414 0
1505 0
9757 0
627 0
969 0
500 0
3277 0
2316 0
8343 0
6151 0
7609 0
7603 0
8419 0
3148 0
8626 0
```

```
  4042 0
  246 0
  6016 0
  9136 0
  5044 0
  9843 0
  8382 0
  1715 0
Tree Properties
  Root Count 0
  First 0
  Last 0
  Root Value 0
Node Details, (crawled in order), value, parent, left, right, red, head, tail, orderCounter

See if values exists
value, exists
  4827 false
  1299 false
  5193 false
  287 false
  7688 false
  5427 false
  2447 false
  9023 false
  4457 false
  9057 false
  7168 false
  9373 false
  1290 false
  6498 false
  7076 false
  2191 false
  1234 false
  3971 false
  1113 false
  7367 false
  4370 false
  4366 false
  1580 false
  7946 false
  2760 false
  4816 false
  5782 false
  7919 false
  7248 false
  4438 false
  6426 false
  8751 false
  9202 false
  4669 false
  4574 false
  6952 false
  8246 false
  9558 false
  2386 false
  4680 false
  4584 false
  4760 false
  4311 false
  4888 false
  5753 false
  544 false
  3471 false
  2915 false
  1760 false
  797 false
  4251 false
  7509 false
  5429 false
  1815 false
  8971 false
```

4641 false
412 false
6180 false
7897 false
8118 false
7940 false
641 false
6497 false
3082 false
6918 false
1005 false
1105 false
9416 false
23 false
396 false
637 false
467 false
7096 false
8187 false
6517 false
6479 false
8779 false
3696 false
4116 false
2283 false
4817 false
1741 false
6465 false
2750 false
9414 false
1505 false
9757 false
627 false
969 false
500 false
3277 false
2316 false
8343 false
6151 false
7609 false
7603 false
8419 false
3148 false
8626 false
4042 false
246 false
6016 false
9136 false
5044 false
9843 false
8382 false
1715 false
4827 false
1299 false
5193 false
287 false
7688 false
5427 false
2447 false
9023 false
4457 false
9057 false
7168 false
9373 false
1290 false
6498 false
7076 false
2191 false
1234 false
3971 false
1113 false
7367 false

4370 false
4366 false
1580 false
7946 false
2760 false
4816 false
5782 false
7919 false
7248 false
4438 false
6426 false
8751 false
9202 false
4669 false
4574 false
6952 false
8246 false
9558 false
2386 false
4680 false
4584 false
4760 false
4311 false
4888 false
5753 false
544 false
3471 false
2915 false
1760 false
797 false
4251 false
7509 false
5429 false
1815 false
8971 false
4641 false
412 false
6180 false
7897 false
8118 false
7940 false
641 false
6497 false
3082 false
6918 false
1005 false
1105 false
9416 false
23 false
396 false
637 false
467 false
7096 false
8187 false
6517 false
6479 false
8779 false
3696 false
4116 false
2283 false
4817 false
1741 false
6465 false
2750 false
9414 false
1505 false
9757 false
627 false
969 false
500 false
3277 false
2316 false

```
8343 false
6151 false
7609 false
7603 false
8419 false
3148 false
8626 false
4042 false
246 false
6016 false
9136 false
5044 false
9843 false
8382 false
1715 false
  ✓ Insert all orders and delete after

ProxyController
  Initialize
    ✓ Deploy a ProxyController contract
  Register contracts
    ✓ Register a CurrencyController contract
    ✓ Fail to set a contract due to invalid caller
    ✓ Update a CurrencyController contract
    ✓ Fail to set a contract due to invalid input
    ✓ Register multiple contracts using multicall
    ✓ Fail to register contracts due to execution by non-owner
  Get contract address
    ✓ Successfully get a proxy address
    ✓ Fail to get a proxy address due to empty data
    ✓ Fail to call a contract due to missing address
  Use contracts through the Proxy
    ✓ Successfully call a CurrencyController contract
    ✓ Fail to call a CurrencyController contract due to direct access
  Change Admin
    ✓ Successfully change admins of a proxy contract
    ✓ Fail to change admins of a proxy contract due to execution by non-owner

ReserveFund
  Initialize
    ✓ Fail to call initialization due to duplicate execution
    ✓ Fail to call initialization due to execution by non-proxy contract
  Pause
    ✓ Pause and Unpause
    ✓ Change the operator
    ✓ Remove operator role from another user
    ✓ Fail to pause due to non-operator caller
    ✓ Fail to unpause due to non-operator caller
    ✓ Fail to revoke role due to own role
    ✓ Fail to renounce role due to not allowed access
  Deposit
    ✓ Deposit ERC20 token
    ✓ Deposit ETH
    ✓ Fail to deposit token due to execution by non-owner
  Withdraw
    ✓ Withdraw funds
    ✓ Fail to withdraw token due to execution by non-owner
  Execute transaction
    ✓ Execute emergency settlement
    ✓ Execute a deposit transaction
    ✓ Fail to execute a transaction due to execution by non-owner
    ✓ Fail to execute transactions due to execution by non-owner
    ✓ Fail to execute transactions due to empty inputs
    ✓ Fail to execute transactions due to input array length mismatch: _data
    ✓ Fail to execute transactions due to input array length mismatch: _values

BokkyPooBahsDateTimeContract
  Test functions library functions
    Test basic read time functions
      ✓ timestampToDate
      ✓ getDaysInMonth
      ✓ getDayOfWeek
```

```
      ✓ getYear
      ✓ getMonth
      ✓ getDay
      ✓ getHour
      ✓ getMinute
    Test basic time addition functions
      ✓ addedYears
      ✓ addMonths
      ✓ addDays
      ✓ addHours
      ✓ addMinutes
    Test basic time subtraction functions
      ✓ subYears
      ✓ subMonths
      ✓ subDays
      ✓ subHours
      ✓ subMinutes
    Test basic time difference functions
      ✓ diffYears
      ✓ diffMonths
      ✓ diffDays
      ✓ diffHours
      ✓ diffMinutes

TokenVault
  Initialize
    ✓ Get liquidation threshold rate
    ✓ Update the liquidation configuration
    ✓ Fail to call updateLiquidationConfiguration due to invalid rate
    ✓ Fail to call initialization due to duplicate execution
    ✓ Fail to call initialization due to execution by non-proxy contract
  Currencies
    ✓ Register currency
    ✓ Update collateral currency to non-collateral currency
    ✓ Register non-collateral currency to collateral currency
    ✓ Fail to receive ETH due to execution by non-WETH contract
    ✓ Fail to register currency due to execution by non-owner
    ✓ Fail to update currency due to execution by non-owner
    ✓ Fail to register currency due to nonexistent currency
    ✓ Fail to register currency due to duplicate registration
    ✓ Fail to register currency due to zero address
    ✓ Fail to register currency due to market termination
    ✓ Fail to update currency due to market termination
  Coverage
    ✓ Calculate the coverage without deposit
    ✓ Calculate the coverage with deposit
    ✓ Calculate the coverage for borrowing orders
    ✓ Calculate the coverage for lending orders
    ✓ Calculate the coverage for lending orders that exceed the deposit amount.
  Deposit & Withdraw
    ✓ Deposit ERC20 token
    ✓ Deposit ETH
    ✓ Deposit ETH to another user
    ✓ Deposit multiple tokens using multicall
    ✓ Deposit to another user with permit
    ✓ Deposit from another user with permit
    ✓ Get the withdrawable amount with the working orders & Withdraw collateral
    ✓ Get the withdrawable amount with the borrowed amount
    ✓ Get the withdrawable amount with with the debt amount
    ✓ Add and remove the collateral amount
    ✓ Reset the collateral amount
    ✓ Add an amount in a currency that is not accepted as collateral
    ✓ Get the withdrawable amount per currency
    ✓ Get the withdrawable amount per currency with the borrowing working orders
    ✓ Get the withdrawable amount per currency with the lending working orders
    ✓ Get the liquidation amount
    ✓ Get the liquidation amount decreased by a maximum
    ✓ Get the liquidation fees
    ✓ Get liquidation amount with no collateral
    ✓ Get liquidation amount with no used collateral
    ✓ Fail to deposit token due to unregistered currency
    ✓ Fail to withdraw token due to unregistered currency
```

```
      ✓ Fail to call addDepositAmount due to unregistered currency
      ✓ Fail to call removeDepositAmount due to unregistered currency
      ✓ Fail to call executeForcedReset due to unregistered currency
      ✓ Fail to call transferFrom due to unregistered currency
      ✓ Fail to call addDepositAmount due to invalid caller
      ✓ Fail to call removeDepositAmount due to invalid caller
      ✓ Fail to call executeForcedReset due to invalid caller
      ✓ Fail to call transferFrom due to invalid caller
      ✓ Fail to call depositWithPermitFrom due to invalid caller
      ✓ Fail to call addDepositAmount due to invalid amount
      ✓ Fail to call deposit due to zero amount
      ✓ Fail to call withdraw due to zero amount
      ✓ Fail to call deposit due to no transfer of native token
      ✓ Fail to deposit token due to transfer of native token
      ✓ Fail to call deposit due to lending market termination
      ✓ Fail to withdraw due to redemption required
      ✓ Fail to withdraw due to insolvency
      ✓ Deposit funds from Alice
      ✓ Withdraw funds from Alice
      ✓ Fail to call depositFrom due to lending market termination
      ✓ Fail to call depositWithPermitTo due to lending market termination
      ✓ Fail to depositWithPermitFrom due to lending market termination
    Transfer
      ✓ Transfer from Alice to Bob
      ✓ Transfer from Alice to Bob with over amount
      ✓ Transfer the deposit amount of Alice, who has a lent amount..
      ✓ Fail to transfer deposits due to invalid caller
    Pause/Unpause operations
      ✓ Pause token vault
      ✓ Unpause token vault
      ✓ Change the operator
    Borrowable amount calculations
      ✓ Without collateral
      ✓ With collateral, unused
      ✓ With collateral, partially used
      ✓ With collateral, totally used
      ✓ Without collateral, has claimable amount
      ✓ With collateral, has claimable amount
      ✓ With collateral, has funds (claimable > collateral)
      ✓ With collateral, has funds (claimable == collateral)

  ZCToken
    Initialization
      ✓ Get correct name, symbol, asset, and maturity
    Minting and Burning
      ✓ Mint tokens successfully
      ✓ Burn tokens successfully
      ✓ Fail to mint tokens by non-authorized addresses
      ✓ Fail to burn tokens by non-authorized addresses
    Permit
      ✓ Get domain separator
      ✓ Accept owner signature
      ✓ Reject reused signature
      ✓ Reject other signature
      ✓ Reject other signature

·------------------------------------------------------------------------|----------------------------|-------------|-----------------------------·
|                          [90mSolc version: 0.8.19[39m                            ·  [90mOptimizer enabled: true[39m  ·  [90mRuns: 200[39m  ·  [90mBlock limit: 30000000 gas[39m  │
·························································································|····························|·············|·····························
|  [32m[1mMethods[22m[39m                                                                                                                                              │
·······························|·········································|·············|·············|·············|···············|·············
|  [1mContract[22m                    ·  [1mMethod[22m                                 ·  [32mMin[39m  ·  [32mMax[39m      ·  [32mAvg[39m      ·  [1m# calls[22m     ·  [1musd (avg)[22m  │
·······························|·········································|·············|·············|·············|···············|·············
|  [90mAddressResolver[39m            ·  importAddresses                          ·      [36m35714[39m  ·  [31m491154[39m  ·     319082  ·         [90m120[39m  ·         [32m[90m-[32m[39m  │
```

```
································|·········································|·············|·············|
·············|···············|·············
|  [90mBeaconProxyController [39m        ·  changeBeaconProxyAdmins                  ·          –  ·
–  ·      40561  ·             [90m1 [39m  ·           [32m [90m– [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mBeaconProxyController [39m        ·  multicall                                ·     [36m190332 [39m  ·
 [31m1037566 [39m  ·     559194  ·              [90m3 [39m  ·           [32m [90m– [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mBeaconProxyController [39m        ·  setFutureValueVaultImpl                  ·      [36m48875 [39m  ·
 [31m346234 [39m  ·     337614  ·            [90m69 [39m  ·           [32m [90m– [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mBeaconProxyController [39m        ·  setLendingMarketImpl                     ·      [36m48800 [39m  ·
 [31m346159 [39m  ·     329638  ·            [90m54 [39m  ·           [32m [90m– [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mBeaconProxyController [39m        ·  setZCTokenImpl                           ·     [36m346189 [39m  ·
 [31m346201 [39m  ·     346199  ·            [90m45 [39m  ·           [32m [90m– [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mBeaconProxyControllerCaller [39m  ·  deployFutureValueVault                   ·          –  ·
–  ·     472341  ·             [90m2 [39m  ·           [32m [90m– [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mBeaconProxyControllerCaller [39m  ·  deployLendingMarket                      ·          –  ·
–  ·     576781  ·             [90m1 [39m  ·           [32m [90m– [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mCurrencyController [39m           ·  addCurrency                              ·      [36m79628 [39m  ·
 [31m305417 [39m  ·     252293  ·           [90m105 [39m  ·           [32m [90m– [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mCurrencyController [39m           ·  removeCurrency                           ·      [36m36672 [39m  ·
 [31m36682 [39m  ·      36675  ·             [90m7 [39m  ·           [32m [90m– [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mCurrencyController [39m           ·  updateHaircut                            ·      [36m33389 [39m  ·
 [31m55313 [39m  ·      39751  ·             [90m8 [39m  ·           [32m [90m– [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mCurrencyController [39m           ·  updatePriceFeed                          ·      [36m78923 [39m  ·
 [31m157785 [39m  ·     118354  ·             [90m4 [39m  ·           [32m [90m– [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mERC20 [39m                        ·  transfer                                 ·          –  ·
–  ·      57382  ·             [90m1 [39m  ·           [32m [90m– [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mFutureValueVaultCaller [39m       ·  decrease                                 ·          –  ·
–  ·     112258  ·             [90m4 [39m  ·           [32m [90m– [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mFutureValueVaultCaller [39m       ·  deployFutureValueVault                   ·          –  ·
–  ·     472756  ·            [90m27 [39m  ·           [32m [90m– [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mFutureValueVaultCaller [39m       ·  executeForcedReset                       ·      [36m43701 [39m  ·
 [31m47130 [39m  ·      45416  ·             [90m4 [39m  ·           [32m [90m– [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mFutureValueVaultCaller [39m       ·  executeForcedReset                       ·      [36m42810 [39m  ·
 [31m46013 [39m  ·      44412  ·             [90m4 [39m  ·           [32m [90m– [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mFutureValueVaultCaller [39m       ·  increase                                 ·     [36m112064 [39m  ·
 [31m112076 [39m  ·     112075  ·            [90m11 [39m  ·           [32m [90m– [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mFutureValueVaultCaller [39m       ·  lock                                     ·          –  ·
–  ·      66696  ·             [90m4 [39m  ·           [32m [90m– [32m [39m  |
```

```
································|·········································|·············|·············|
·············|···············|·············
|  [90mFutureValueVaultCaller [39m      ·  transferFrom                        ·          -  ·
-  ·      92526  ·            [90m2 [39m  ·          [32m [90m- [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mFutureValueVaultCaller [39m      ·  unlock                              ·          -  ·
-  ·      68965  ·            [90m2 [39m  ·          [32m [90m- [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mGenesisValueVaultCaller [39m     ·  cleanUpBalance                      ·     [36m40274 [39m  ·
 [31m121920 [39m  ·     81097  ·            [90m4 [39m  ·          [32m [90m- [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mGenesisValueVaultCaller [39m     ·  executeAutoRoll                     ·    [36m171382 [39m  ·
 [31m171494 [39m  ·    171484  ·           [90m18 [39m  ·          [32m [90m- [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mGenesisValueVaultCaller [39m     ·  executeForcedReset                  ·     [36m49447 [39m  ·
 [31m54222 [39m  ·     51835  ·            [90m4 [39m  ·          [32m [90m- [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mGenesisValueVaultCaller [39m     ·  executeForcedReset                  ·          -  ·
-  ·      37997  ·            [90m2 [39m  ·          [32m [90m- [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mGenesisValueVaultCaller [39m     ·  initializeCurrencySetting           ·    [36m240643 [39m  ·
 [31m240655 [39m  ·    240654  ·           [90m46 [39m  ·          [32m [90m- [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mGenesisValueVaultCaller [39m     ·  lock                                ·          -  ·
-  ·      66230  ·            [90m4 [39m  ·          [32m [90m- [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mGenesisValueVaultCaller [39m     ·  transferFrom                        ·          -  ·
-  ·      61245  ·            [90m2 [39m  ·          [32m [90m- [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mGenesisValueVaultCaller [39m     ·  unlock                              ·          -  ·
-  ·      65362  ·            [90m2 [39m  ·          [32m [90m- [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mGenesisValueVaultCaller [39m     ·  updateGenesisValueWithFutureValue   ·     [36m65999 [39m  ·
 [31m137614 [39m  ·    123850  ·           [90m28 [39m  ·          [32m [90m- [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mGenesisValueVaultCaller [39m     ·  updateGenesisValueWithResidualAmount  ·          -  ·
-  ·     107844  ·            [90m1 [39m  ·          [32m [90m- [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mGenesisValueVaultCaller [39m     ·  updateInitialCompoundFactor         ·          -  ·
-  ·      70755  ·            [90m1 [39m  ·          [32m [90m- [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mLendingMarket [39m               ·  pause                               ·     [36m52116 [39m  ·
 [31m52503 [39m  ·     52227  ·            [90m7 [39m  ·          [32m [90m- [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mLendingMarket [39m               ·  unpause                             ·     [36m30249 [39m  ·
 [31m30611 [39m  ·     30352  ·            [90m7 [39m  ·          [32m [90m- [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mLendingMarketCaller [39m         ·  cleanUpOrders                       ·     [36m86268 [39m  ·
 [31m86308 [39m  ·     86288  ·            [90m4 [39m  ·          [32m [90m- [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mLendingMarketCaller [39m         ·  createOrderBook                     ·     [36m81039 [39m  ·
 [31m186456 [39m  ·    148939  ·          [90m579 [39m  ·          [32m [90m- [32m [39m  |
································|·········································|·············|·············|
·············|···············|·············
|  [90mLendingMarketCaller [39m         ·  deployLendingMarket                 ·    [36m576978 [39m  ·
 [31m576990 [39m  ·    576984  ·           [90m14 [39m  ·          [32m [90m- [32m [39m  |
```

```
·····························|····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketCaller [39m        ·  executeAutoRoll                    ·      [36m49823 [39m  ·
 [31m70116 [39m  ·      49869  ·          [90m511 [39m  ·          [32m [90m– [32m [39m  │
·····························|····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketCaller [39m        ·  executeItayoseCall                 ·      [36m95518 [39m  ·
 [31m307048 [39m  ·     189394  ·           [90m20 [39m  ·          [32m [90m– [32m [39m  │
·····························|····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketCaller [39m        ·  executeOrder                       ·     [36m123572 [39m  ·
 [31m395310 [39m  ·     266631  ·          [90m206 [39m  ·          [32m [90m– [32m [39m  │
·····························|····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketCaller [39m        ·  executePreOrder                    ·     [36m340586 [39m  ·
 [31m403113 [39m  ·     369038  ·           [90m57 [39m  ·          [32m [90m– [32m [39m  │
·····························|····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketCaller [39m        ·  pause                              ·          –  ·
–  ·      63189  ·            [90m1 [39m  ·          [32m [90m– [32m [39m  │
·····························|····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketCaller [39m        ·  unpause                            ·          –  ·
–  ·      41299  ·            [90m1 [39m  ·          [32m [90m– [32m [39m  │
·····························|····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketCaller [39m        ·  unwindPosition                     ·      [36m95806 [39m  ·
 [31m159191 [39m  ·     139917  ·            [90m5 [39m  ·          [32m [90m– [32m [39m  │
·····························|····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketController [39m    ·  cancelOrder                        ·     [36m123205 [39m  ·
 [31m143504 [39m  ·     125455  ·           [90m25 [39m  ·          [32m [90m– [32m [39m  │
·····························|····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketController [39m    ·  cleanUpAllFunds                    ·     [36m145164 [39m  ·
 [31m731232 [39m  ·     344851  ·           [90m26 [39m  ·          [32m [90m– [32m [39m  │
·····························|····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketController [39m    ·  createOrderBook                    ·    [36m1026889 [39m  ·
 [31m1086599 [39m  ·    1054406  ·         [90m1344 [39m  ·          [32m [90m– [32m [39m  │
·····························|····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketController [39m    ·  depositAndExecuteOrder             ·     [36m588142 [39m  ·
 [31m1242019 [39m  ·     883588  ·          [90m229 [39m  ·          [32m [90m– [32m [39m  │
·····························|····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketController [39m    ·  depositAndExecutesPreOrder         ·     [36m642620 [39m  ·
 [31m853037 [39m  ·     800427  ·            [90m4 [39m  ·          [32m [90m– [32m [39m  │
·····························|····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketController [39m    ·  depositWithPermitAndExecuteOrder   ·     [36m593668 [39m  ·
 [31m940565 [39m  ·     839979  ·            [90m4 [39m  ·          [32m [90m– [32m [39m  │
·····························|····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketController [39m    ·  depositWithPermitAndExecutePreOrder ·     [36m584280 [39m  ·
 [31m881826 [39m  ·     683462  ·            [90m3 [39m  ·          [32m [90m– [32m [39m  │
·····························|····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketController [39m    ·  depositZCToken                     ·     [36m181716 [39m  ·
 [31m309321 [39m  ·     217459  ·           [90m16 [39m  ·          [32m [90m– [32m [39m  │
·····························|····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketController [39m    ·  executeEmergencySettlement         ·     [36m278134 [39m  ·
 [31m707185 [39m  ·     449484  ·           [90m36 [39m  ·          [32m [90m– [32m [39m  │
·····························|····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketController [39m    ·  executeEmergencyTermination        ·     [36m213984 [39m  ·
 [31m472202 [39m  ·     322206  ·           [90m24 [39m  ·          [32m [90m– [32m [39m  │
·····························|····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketController [39m    ·  executeForcedRepayment             ·     [36m430490 [39m  ·
 [31m566784 [39m  ·     494189  ·            [90m9 [39m  ·          [32m [90m– [32m [39m  │
```

```
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketController [39m     ·  executeItayoseCall                  ·     [36m119947 [39m  ·
 [31m460843 [39m  ·     127326  ·          [90m901 [39m  ·          [32m [90m- [32m [39m  │
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketController [39m     ·  executeLiquidationCall              ·     [36m613368 [39m  ·
 [31m1133269 [39m  ·     722364  ·           [90m14 [39m  ·          [32m [90m- [32m [39m  │
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketController [39m     ·  executeOrder                        ·     [36m263813 [39m  ·
 [31m1641072 [39m  ·     717474  ·         [90m3168 [39m  ·          [32m [90m- [32m [39m  │
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketController [39m     ·  executePreOrder                     ·     [36m341329 [39m  ·
 [31m749290 [39m  ·     549509  ·           [90m99 [39m  ·          [32m [90m- [32m [39m  │
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketController [39m     ·  executeRedemption                   ·     [36m227505 [39m  ·
 [31m275076 [39m  ·     252072  ·            [90m5 [39m  ·          [32m [90m- [32m [39m  │
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketController [39m     ·  executeRepayment                    ·     [36m318787 [39m  ·
 [31m437707 [39m  ·     366530  ·            [90m5 [39m  ·          [32m [90m- [32m [39m  │
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketController [39m     ·  initializeLendingMarket             ·    [36m2021323 [39m  ·
 [31m2046731 [39m  ·    2037125  ·          [90m269 [39m  ·          [32m [90m- [32m [39m  │
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketController [39m     ·  migrateLendingMarket                ·     [36m811874 [39m  ·
 [31m815064 [39m  ·     812672  ·            [90m4 [39m  ·          [32m [90m- [32m [39m  │
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketController [39m     ·  pauseLendingMarket                  ·          -  ·
-  ·      76424  ·            [90m3 [39m  ·          [32m [90m- [32m [39m  │
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketController [39m     ·  rotateOrderBooks                    ·    [36m1284096 [39m  ·
 [31m1585840 [39m  ·    1417656  ·          [90m938 [39m  ·          [32m [90m- [32m [39m  │
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketController [39m     ·  unpauseLendingMarket                ·          -  ·
-  ·      54593  ·            [90m2 [39m  ·          [32m [90m- [32m [39m  │
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketController [39m     ·  unwindPosition                      ·     [36m460664 [39m  ·
 [31m650500 [39m  ·     545114  ·           [90m15 [39m  ·          [32m [90m- [32m [39m  │
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketController [39m     ·  updateCircuitBreakerLimitRange      ·          -  ·
-  ·      52761  ·            [90m2 [39m  ·          [32m [90m- [32m [39m  │
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketController [39m     ·  updateMinDebtUnitPrice              ·          -  ·
-  ·      41298  ·            [90m1 [39m  ·          [32m [90m- [32m [39m  │
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketController [39m     ·  updateOrderFeeRate                  ·          -  ·
-  ·      59531  ·            [90m2 [39m  ·          [32m [90m- [32m [39m  │
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mLendingMarketController [39m     ·  withdrawZCToken                     ·     [36m464549 [39m  ·
 [31m846228 [39m  ·     566968  ·           [90m34 [39m  ·          [32m [90m- [32m [39m  │
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mLiquidator [39m                  ·  addOperator                         ·      [36m56526 [39m  ·
 [31m56614 [39m  ·      56578  ·            [90m4 [39m  ·         [32m [90m- [32m [39m  │
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mLiquidator [39m                  ·  deposit                             ·      [36m59234 [39m  ·
 [31m206597 [39m  ·     161701  ·          [90m1128 [39m  ·          [32m [90m- [32m [39m  │
```

```
································|·········································|·············|·············|
·············|················|·············
|  [90mLiquidator[39m                    ·  executeForcedRepayment                ·    [36m1075575[39m  ·
 [31m1179112[39m  ·    1120205  ·            [90m8[39m  ·          [32m[90m–[32m[39m  │
································|·········································|·············|·············|
·············|················|·············
|  [90mLiquidator[39m                    ·  executeLiquidationCall                ·    [36m1733439[39m  ·
 [31m3296266[39m  ·    2111931  ·           [90m21[39m  ·          [32m[90m–[32m[39m  │
································|·········································|·············|·············|
·············|················|·············
|  [90mLiquidator[39m                    ·  executeTransaction                    ·      [36m43254[39m  ·
 [31m600260[39m  ·     299929  ·           [90m14[39m  ·          [32m[90m–[32m[39m  │
································|·········································|·············|·············|
·············|················|·············
|  [90mLiquidator[39m                    ·  executeTransactions                   ·      [36m65599[39m  ·
 [31m131966[39m  ·     108106  ·            [90m9[39m  ·          [32m[90m–[32m[39m  │
································|·········································|·············|·············|
·············|················|·············
|  [90mLiquidator[39m                    ·  removeOperator                        ·      [36m34690[39m  ·
 [31m34747[39m  ·      34728  ·            [90m3[39m  ·          [32m[90m–[32m[39m  │
································|·········································|·············|·············|
·············|················|·············
|  [90mLiquidator[39m                    ·  renounceOwnership                     ·          –  ·
–  ·      28815  ·            [90m1[39m  ·          [32m[90m–[32m[39m  │
································|·········································|·············|·············|
·············|················|·············
|  [90mLiquidator[39m                    ·  revokeRole                            ·          –  ·
–  ·      35182  ·            [90m1[39m  ·          [32m[90m–[32m[39m  │
································|·········································|·············|·············|
·············|················|·············
|  [90mLiquidator[39m                    ·  transferOwnership                     ·          –  ·
–  ·      34224  ·            [90m1[39m  ·          [32m[90m–[32m[39m  │
································|·········································|·············|·············|
·············|················|·············
|  [90mLiquidator[39m                    ·  withdraw                              ·      [36m58241[39m  ·
 [31m670917[39m  ·     325162  ·           [90m70[39m  ·          [32m[90m–[32m[39m  │
································|·········································|·············|·············|
·············|················|·············
|  [90mMigrationAddressResolver[39m      ·  buildCaches                           ·      [36m72006[39m  ·
 [31m433840[39m  ·     171084  ·          [90m104[39m  ·          [32m[90m–[32m[39m  │
································|·········································|·············|·············|
·············|················|·············
|  [90mMockERC20[39m                     ·  approve                               ·          –  ·
–  ·      46302  ·            [90m1[39m  ·          [32m[90m–[32m[39m  │
································|·········································|·············|·············|
·············|················|·············
|  [90mMockERC20[39m                     ·  permit                                ·          –  ·
–  ·      92372  ·            [90m2[39m  ·          [32m[90m–[32m[39m  │
································|·········································|·············|·············|
·············|················|·············
|  [90mMockERC20[39m                     ·  transfer                              ·          –  ·
–  ·      46656  ·            [90m1[39m  ·          [32m[90m–[32m[39m  │
································|·········································|·············|·············|
·············|················|·············
|  [90mMockUniswapRouter[39m             ·  setToken                              ·      [36m44189[39m  ·
 [31m44201[39m  ·      44197  ·            [90m3[39m  ·          [32m[90m–[32m[39m  │
································|·········································|·············|·············|
·············|················|·············
|  [90mMockUSDC[39m                      ·  approve                               ·      [36m26702[39m  ·
 [31m46602[39m  ·      44584  ·          [90m120[39m  ·          [32m[90m–[32m[39m  │
································|·········································|·············|·············|
·············|················|·············
|  [90mMockUSDC[39m                      ·  transfer                              ·      [36m51396[39m  ·
 [31m51456[39m  ·      51431  ·          [90m161[39m  ·          [32m[90m–[32m[39m  │
································|·········································|·············|·············|
·············|················|·············
|  [90mMockV3Aggregator[39m              ·  updateAnswer                          ·     [36m102972[39m  ·
 [31m105808[39m  ·     104511  ·           [90m46[39m  ·          [32m[90m–[32m[39m  │
································|·········································|·············|·············|
·············|················|·············
|  [90mMockWBTC[39m                      ·  approve                               ·          –  ·
–  ·      46266  ·            [90m8[39m  ·          [32m[90m–[32m[39m  │
```

```
·································|··········································|··············|··············|
··············|················|··············
|  [90mMockWBTC[39m                      ·  transfer                                 ·      [36m51420[39m  ·
[31m51432[39m  ·      51431  ·           [90m26[39m  ·          [32m[90m–[32m[39m  |
·································|··········································|··············|··············|
··············|················|··············
|  [90mMockWFIL[39m                      ·  approve                                  ·      [36m29214[39m  ·
[31m46602[39m  ·      46255  ·          [90m891[39m  ·          [32m[90m–[32m[39m  |
·································|··········································|··············|··············|
··············|················|··············
|  [90mMockWFIL[39m                      ·  transfer                                 ·      [36m34368[39m  ·
[31m51480[39m  ·      51392  ·          [90m962[39m  ·          [32m[90m–[32m[39m  |
·································|··········································|··············|··············|
··············|················|··············
|  [90mOrderStatisticsTreeContract[39m  ·  dropValuesFromFirst                      ·      [36m36226[39m  ·
[31m182465[39m  ·      84911  ·           [90m215[39m  ·          [32m[90m–[32m[39m  |
·································|··········································|··············|··············|
··············|················|··············
|  [90mOrderStatisticsTreeContract[39m  ·  dropValuesFromLast                       ·      [36m36247[39m  ·
[31m215352[39m  ·      86547  ·           [90m215[39m  ·          [32m[90m–[32m[39m  |
·································|··········································|··············|··············|
··············|················|··············
|  [90mOrderStatisticsTreeContract[39m  ·  insertAmountValue                        ·      [36m95653[39m  ·
[31m325118[39m  ·     169546  ·          [90m2573[39m  ·          [32m[90m–[32m[39m  |
·································|··········································|··············|··············|
··············|················|··············
|  [90mOrderStatisticsTreeContract[39m  ·  removeAmountValue                        ·      [36m59914[39m  ·
[31m206332[39m  ·     117150  ·           [90m107[39m  ·          [32m[90m–[32m[39m  |
·································|··········································|··············|··············|
··············|················|··············
|  [90mProxyController[39m               ·  changeProxyAdmins                        ·          –  ·
–  ·      35374  ·            [90m1[39m  ·          [32m[90m–[32m[39m  |
·································|··········································|··············|··············|
··············|················|··············
|  [90mProxyController[39m               ·  multicall                                ·          –  ·
–  ·     761601  ·            [90m2[39m  ·          [32m[90m–[32m[39m  |
·································|··········································|··············|··············|
··············|················|··············
|  [90mProxyController[39m               ·  setAddressResolverImpl                   ·     [36m392728[39m  ·
[31m392740[39m  ·     392739  ·           [90m136[39m  ·          [32m[90m–[32m[39m  |
·································|··········································|··············|··············|
··············|················|··············
|  [90mProxyController[39m               ·  setBeaconProxyControllerImpl             ·     [36m406227[39m  ·
[31m406239[39m  ·     406238  ·           [90m202[39m  ·          [32m[90m–[32m[39m  |
·································|··········································|··············|··············|
··············|················|··············
|  [90mProxyController[39m               ·  setCurrencyControllerImpl                ·      [36m54431[39m  ·
[31m383156[39m  ·     351546  ·            [90m52[39m  ·          [32m[90m–[32m[39m  |
·································|··········································|··············|··············|
··············|················|··············
|  [90mProxyController[39m               ·  setGenesisValueVaultImpl                 ·     [36m381726[39m  ·
[31m381738[39m  ·     381737  ·            [90m74[39m  ·          [32m[90m–[32m[39m  |
·································|··········································|··············|··············|
··············|················|··············
|  [90mProxyController[39m               ·  setLendingMarketControllerImpl           ·     [36m478468[39m  ·
[31m478480[39m  ·     478479  ·            [90m70[39m  ·          [32m[90m–[32m[39m  |
·································|··········································|··············|··············|
··············|················|··············
|  [90mProxyController[39m               ·  setReserveFundImpl                       ·     [36m481544[39m  ·
[31m481556[39m  ·     481553  ·            [90m36[39m  ·          [32m[90m–[32m[39m  |
·································|··········································|··············|··············|
··············|················|··············
|  [90mProxyController[39m               ·  setTokenVaultImpl                        ·     [36m578931[39m  ·
[31m578943[39m  ·     578940  ·            [90m36[39m  ·          [32m[90m–[32m[39m  |
·································|··········································|··············|··············|
··············|················|··············
|  [90mTokenVault[39m                    ·  depositTo                                ·     [36m163297[39m  ·
[31m180520[39m  ·     174779  ·             [90m3[39m  ·          [32m[90m–[32m[39m  |
·································|··········································|··············|··············|
··············|················|··············
|  [90mTokenVault[39m                    ·  depositWithPermitTo                      ·      [36m96064[39m  ·
[31m201924[39m  ·     163334  ·             [90m4[39m  ·          [32m[90m–[32m[39m  |
```

```
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mTokenVault [39m                ·  registerCurrency                    ·      [36m80240 [39m  ·
 [31m154507 [39m  ·     109183  ·          [90m142 [39m  ·          [32m [90m- [32m [39m  |
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mTokenVault [39m                ·  updateCurrency                      ·      [36m48294 [39m  ·
 [31m112778 [39m  ·      99483  ·           [90m35 [39m  ·          [32m [90m- [32m [39m  |
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mTokenVault [39m                ·  updateLiquidationConfiguration      ·      [36m38526 [39m  ·
 [31m47657 [39m  ·      39931  ·          [90m13 [39m  ·          [32m [90m- [32m [39m  |
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mTokenVaultCaller [39m          ·  addDepositAmount                    ·      [36m51163 [39m  ·
 [31m132772 [39m  ·     113030  ·           [90m5 [39m  ·          [32m [90m- [32m [39m  |
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mTokenVaultCaller [39m          ·  cleanUpFunds                        ·      [36m78264 [39m  ·
 [31m578485 [39m  ·     238871  ·          [90m48 [39m  ·          [32m [90m- [32m [39m  |
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mTokenVaultCaller [39m          ·  cleanUpUsedCurrencies               ·          -  ·
-  ·      47078  ·           [90m1 [39m  ·          [32m [90m- [32m [39m  |
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mTokenVaultCaller [39m          ·  depositFrom                         ·     [36m123428 [39m  ·
 [31m170801 [39m  ·     158958  ·           [90m4 [39m  ·          [32m [90m- [32m [39m  |
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mTokenVaultCaller [39m          ·  depositWithPermitFrom               ·          -  ·
-  ·     180915  ·           [90m2 [39m  ·          [32m [90m- [32m [39m  |
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mTokenVaultCaller [39m          ·  executeForcedReset                  ·          -  ·
-  ·      49884  ·           [90m1 [39m  ·          [32m [90m- [32m [39m  |
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mTokenVaultCaller [39m          ·  removeDepositAmount                 ·      [36m44370 [39m  ·
 [31m49134 [39m  ·      46752  ·           [90m2 [39m  ·          [32m [90m- [32m [39m  |
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mTokenVaultCaller [39m          ·  transferFrom                        ·     [36m137334 [39m  ·
 [31m160082 [39m  ·     152191  ·           [90m7 [39m  ·          [32m [90m- [32m [39m  |
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mZCTokenCaller [39m             ·  burn                                ·          -  ·
-  ·      43111  ·           [90m2 [39m  ·          [32m [90m- [32m [39m  |
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mZCTokenCaller [39m             ·  deployZCToken                       ·     [36m727903 [39m  ·
 [31m727915 [39m  ·     727914  ·          [90m10 [39m  ·          [32m [90m- [32m [39m  |
·····························|·····································|···········|···········|
···········|·············|···········
|  [90mZCTokenCaller [39m             ·  mint                                ·          -  ·
-  ·      86647  ·           [90m3 [39m  ·          [32m [90m- [32m [39m  |
·····························|·····································|···········|···········|
···········|·············|···········
|  [32m [1mDeployments [22m [39m                                                 ·
·  [1m% of limit [22m   ·            |
·····························|·····································|···········|···········|
···········|·············|···········
|  AddressResolver                                        ·          -  ·          -  ·
852927  ·        [90m2.8 % [39m  ·          [32m [90m- [32m [39m  |
·····························|·····································|···········|···········|
···········|·············|···········
|  BeaconProxyController                                  ·          -  ·          -  ·
2512625  ·        [90m8.4 % [39m  ·          [32m [90m- [32m [39m  |
·····························|·····································|···········|···········|
···········|·············|···········
|  BeaconProxyControllerCaller                            ·     [36m221760 [39m  ·
 [31m221772 [39m  ·     221771  ·        [90m0.7 % [39m  ·          [32m [90m- [32m [39m  |
```

```
·····························································|·············|·············|
············|··············|·············
|  BokkyPooBahsDateTimeContract                              ·          -  ·          -  ·
1304957  ·        [90m4.3 %[39m  ·          [32m[90m-[32m[39m  |
·····························································|·············|·············|
············|··············|·············
|  CurrencyController                                        ·          -  ·          -  ·
2237966  ·        [90m7.5 %[39m  ·          [32m[90m-[32m[39m  |
·····························································|·············|·············|
············|··············|·············
|  DepositManagementLogic                                    ·          -  ·          -  ·
2101416  ·          [90m7 %[39m  ·          [32m[90m-[32m[39m  |
·····························································|·············|·············|
············|··············|·············
|  FundManagementLogic                                       ·    [36m4527096[39m  ·
 [31m4527108[39m  ·    4527107  ·       [90m15.1 %[39m  ·          [32m[90m-[32m[39m  |
·····························································|·············|·············|
············|··············|·············
|  FutureValueVault                                          ·          -  ·          -  ·
1707829  ·        [90m5.7 %[39m  ·          [32m[90m-[32m[39m  |
·····························································|·············|·············|
············|··············|·············
|  FutureValueVaultCaller                                    ·     [36m508145[39m  ·
 [31m508169[39m  ·     508167  ·        [90m1.7 %[39m  ·          [32m[90m-[32m[39m  |
·····························································|·············|·············|
············|··············|·············
|  GenesisValueVault                                         ·          -  ·          -  ·
2728739  ·        [90m9.1 %[39m  ·          [32m[90m-[32m[39m  |
·····························································|·············|·············|
············|··············|·············
|  GenesisValueVaultCaller                                   ·          -  ·          -  ·
530108  ·        [90m1.8 %[39m  ·          [32m[90m-[32m[39m  |
·····························································|·············|·············|
············|··············|·············
|  LendingMarket                                             ·    [36m3004222[39m  ·
 [31m3004534[39m  ·    3004505  ·         [90m10 %[39m  ·          [32m[90m-[32m[39m  |
·····························································|·············|·············|
············|··············|·············
|  LendingMarketCaller                                       ·     [36m869433[39m  ·
 [31m869445[39m  ·     869445  ·        [90m2.9 %[39m  ·          [32m[90m-[32m[39m  |
·····························································|·············|·············|
············|··············|·············
|  LendingMarketController                                   ·    [36m5002393[39m  ·
 [31m5002597[39m  ·    5002567  ·       [90m16.7 %[39m  ·          [32m[90m-[32m[39m  |
·····························································|·············|·············|
············|··············|·············
|  LendingMarketOperationLogic                               ·          -  ·          -  ·
3535721  ·       [90m11.8 %[39m  ·          [32m[90m-[32m[39m  |
·····························································|·············|·············|
············|··············|·············
|  LendingMarketReader                                       ·    [36m2650315[39m  ·
 [31m2650327[39m  ·    2650326  ·        [90m8.8 %[39m  ·          [32m[90m-[32m[39m  |
·····························································|·············|·············|
············|··············|·············
|  LendingMarketUserLogic                                    ·    [36m2857194[39m  ·
 [31m2857410[39m  ·    2857397  ·        [90m9.5 %[39m  ·          [32m[90m-[32m[39m  |
·····························································|·············|·············|
············|··············|·············
|  LiquidationLogic                                          ·    [36m2039702[39m  ·
 [31m2039870[39m  ·    2039860  ·        [90m6.8 %[39m  ·          [32m[90m-[32m[39m  |
·····························································|·············|·············|
············|··············|·············
|  Liquidator                                                ·    [36m2764932[39m  ·
 [31m2767155[39m  ·    2765575  ·        [90m9.2 %[39m  ·          [32m[90m-[32m[39m  |
·····························································|·············|·············|
············|··············|·············
|  MigrationAddressResolver                                  ·          -  ·          -  ·
192897  ·        [90m0.6 %[39m  ·          [32m[90m-[32m[39m  |
·····························································|·············|·············|
············|··············|·············
|  MockERC20                                                 ·          -  ·          -  ·
1750145  ·        [90m5.8 %[39m  ·          [32m[90m-[32m[39m  |
```

```
····································································|·············|·············|
·············|···············|·············
|  MockUniswapRouter                                                  ·           -  ·           -  ·
1420951  ·         [90m4.7 % [39m  ·           [32m [90m- [32m [39m  |
····································································|·············|·············|
·············|···············|·············
|  MockUSDC                                                           ·    [36m1796892 [39m  ·
 [31m1797000 [39m  ·    1796956  ·           [90m6 % [39m  ·           [32m [90m- [32m [39m  |
····································································|·············|·············|
·············|···············|·············
|  MockV3Aggregator                                                   ·     [36m663084 [39m  ·
 [31m663120 [39m  ·     663103  ·         [90m2.2 % [39m  ·          [32m [90m- [32m [39m  |
····································································|·············|·············|
·············|···············|·············
|  MockWBTC                                                           ·    [36m1796928 [39m  ·
 [31m1797036 [39m  ·    1796961  ·           [90m6 % [39m  ·           [32m [90m- [32m [39m  |
····································································|·············|·············|
·············|···············|·············
|  MockWETH9                                                          ·           -  ·           -  ·
559075  ·         [90m1.9 % [39m  ·           [32m [90m- [32m [39m  |
····································································|·············|·············|
·············|···············|·············
|  MockWFIL                                                           ·    [36m1797174 [39m  ·
 [31m1797294 [39m  ·    1797265  ·           [90m6 % [39m  ·           [32m [90m- [32m [39m  |
····································································|·············|·············|
·············|···············|·············
|  OrderActionLogic                                                   ·    [36m4400638 [39m  ·
 [31m4400686 [39m  ·    4400683  ·        [90m14.7 % [39m  ·           [32m [90m- [32m [39m  |
····································································|·············|·············|
·············|···············|·············
|  OrderBookLogic                                                     ·           -  ·           -  ·
3104881  ·        [90m10.3 % [39m  ·           [32m [90m- [32m [39m  |
····································································|·············|·············|
·············|···············|·············
|  OrderReaderLogic                                                   ·           -  ·           -  ·
1761226  ·         [90m5.9 % [39m  ·           [32m [90m- [32m [39m  |
····································································|·············|·············|
·············|···············|·············
|  OrderStatisticsTreeContract                                        ·           -  ·           -  ·
2623359  ·         [90m8.7 % [39m  ·           [32m [90m- [32m [39m  |
····································································|·············|·············|
·············|···············|·············
|  ProxyController                                                    ·    [36m1723035 [39m  ·
 [31m1750788 [39m  ·    1723231  ·         [90m5.7 % [39m  ·           [32m [90m- [32m [39m  |
····································································|·············|·············|
·············|···············|·············
|  QuickSort                                                          ·           -  ·           -  ·
294449  ·           [90m1 % [39m  ·           [32m [90m- [32m [39m  |
····································································|·············|·············|
·············|···············|·············
|  ReserveFund                                                        ·           -  ·           -  ·
1923568  ·         [90m6.4 % [39m  ·           [32m [90m- [32m [39m  |
····································································|·············|·············|
·············|···············|·············
|  TokenVault                                                         ·    [36m3876672 [39m  ·
 [31m3876924 [39m  ·    3876911  ·        [90m12.9 % [39m  ·           [32m [90m- [32m [39m  |
····································································|·············|·············|
·············|···············|·············
|  TokenVaultCaller                                                   ·           -  ·           -  ·
844077  ·         [90m2.8 % [39m  ·           [32m [90m- [32m [39m  |
····································································|·············|·············|
·············|···············|·············
|  ZCToken                                                            ·           -  ·           -  ·
1903105  ·         [90m6.3 % [39m  ·           [32m [90m- [32m [39m  |
····································································|·············|·············|
·············|···············|·············
|  ZCTokenCaller                                                      ·           -  ·           -  ·
329036  ·         [90m1.1 % [39m  ·           [32m [90m- [32m [39m  |
·-------------------------------------------------------------------|-------------|-------------|-----
--------|---------------|-------------·
```

```
2044 passing (1h)
```

Code Coverage

While line and statement coverage metrics are high, we highly recommend improving the branch coverage to a minimum of 95%.

Fix Review: The test coverage has been slightly improved across the board. We continue to recommend improving branch coverage to a minimum of 95%.

File	% Stmts	% Branch	% Funcs	% Lines	Uncovered Lines
migration/	100	50	100	100	
MigrationAddressResolver.sol	100	50	100	100	
protocol/	98.83	91.8	97.87	99.01	
AddressResolver.sol	100	100	100	100	
BeaconProxyController.sol	100	88.46	100	100	
CurrencyController.sol	100	100	100	100	
FutureValueVault.sol	98	94.12	94.12	98.92	44
GenesisValueVault.sol	99.06	94.74	97.5	98.79	57,432
LendingMarket.sol	98.18	93.55	98.08	98.46	174
LendingMarketController.sol	97.8	83.82	96.67	98.08	138,146
ProxyController.sol	100	92.31	100	100	
ReserveFund.sol	100	100	100	100	
TokenVault.sol	98.33	92.31	97.67	98.73	163
ZCToken.sol	100	75	100	100	
protocol/interfaces/	100	100	100	100	
IAddressResolver.sol	100	100	100	100	
IBeaconProxyController.sol	100	100	100	100	
ICurrencyController.sol	100	100	100	100	
IFutureValueVault.sol	100	100	100	100	
IGenesisValueVault.sol	100	100	100	100	
ILendingMarket.sol	100	100	100	100	
ILendingMarketController.sol	100	100	100	100	
ILiquidationReceiver.sol	100	100	100	100	

File	% Stmts	% Branch	% Funcs	% Lines	Uncovered Lines
INativeToken.sol	100	100	100	100	
IProxyController.sol	100	100	100	100	
IReserveFund.sol	100	100	100	100	
ITokenVault.sol	100	100	100	100	
IZCToken.sol	100	100	100	100	
protocol/libraries/	94.9	83.11	89.63	94.44	
AddressResolverLib.sol	100	100	100	100	
BokkyPooBahsDateTimeLibrary.sol	83.05	54.17	71.79	76.86	... 407,458,459
Constants.sol	100	100	100	100	
Contracts.sol	100	100	100	100	
OrderBookLib.sol	100	94.53	100	100	
OrderStatisticsTreeLib.sol	95.08	87.73	95.65	95.6	... 3,1052,1053
QuickSort.sol	93.33	75	100	100	
TransferHelper.sol	96	69.23	90.91	96.15	14
protocol/libraries/logics/	99.46	91.97	100	98.99	
DepositManagementLogic.sol	97.56	94.44	100	95.45	... 376,379,382
FundManagementLogic.sol	100	94.19	100	99.07	614,1046,1052
LendingMarketOperationLogic.sol	100	93.75	100	100	
LendingMarketUserLogic.sol	99.2	94.05	100	99.35	706
LiquidationLogic.sol	100	82.26	100	98.97	374
OrderActionLogic.sol	100	89.47	100	100	
OrderBookLogic.sol	100	86.36	100	100	
OrderReaderLogic.sol	97.22	94.44	100	100	
protocol/libraries/math/	100	80	100	100	
RoundingInt256.sol	100	83.33	100	100	
RoundingUint256.sol	100	75	100	100	
protocol/mixins/	95.52	90.38	88.24	96.43	

File	% Stmts	% Branch	% Funcs	% Lines	Uncovered Lines
MixinAccessControl.sol	100	100	100	100	
MixinAddressResolver.sol	85.71	75	69.23	88	73,81,89
MixinLendingMarketConfiguration.sol	100	100	100	100	
MixinLiquidationConfiguration.sol	100	95	100	100	
MixinWallet.sol	100	87.5	100	100	
protocol/storages/	100	100	100	100	
AddressResolverStorage.sol	100	100	100	100	
BeaconProxyControllerStorage.sol	100	100	100	100	
CurrencyControllerStorage.sol	100	100	100	100	
FutureValueVaultStorage.sol	100	100	100	100	
GenesisValueVaultStorage.sol	100	100	100	100	
LendingMarketControllerStorage.sol	100	100	100	100	
LendingMarketStorage.sol	100	100	100	100	
ReserveFundStorage.sol	100	100	100	100	
TokenVaultStorage.sol	100	100	100	100	
ZCTokenStorage.sol	100	100	100	100	
protocol/storages/libraries/	100	100	100	100	
TransferHelperStorage.sol	100	100	100	100	
protocol/storages/mixins/	100	100	100	100	
MixinAddressResolverStorage.sol	100	100	100	100	
protocol/storages/utils/	100	100	100	100	
AccessControlStorage.sol	100	100	100	100	
EIP712UpgradeableStorage.sol	100	100	100	100	
ERC20PermitUpgradeableStorage.sol	100	100	100	100	
ERC20UpgradeableStorage.sol	100	100	100	100	

File	% Stmts	% Branch	% Funcs	% Lines	Uncovered Lines
OwnableStorage.sol	100	100	100	100	
PausableStorage.sol	100	100	100	100	
protocol/types/	100	100	100	100	
ProtocolTypes.sol	100	100	100	100	
protocol/utils/	74.19	56.1	84.21	78.18	
AccessControl.sol	61.11	35.71	69.23	63.64	... 216,217,218
EIP712Upgradeable.sol	66.67	50	80	84.62	57,113
ERC20PermitUpgradeable.sol	100	100	100	100	
ERC20Upgradeable.sol	58.33	36.36	68.42	64.52	... 305,306,307
LockAndMsgSender.sol	100	50	100	83.33	17
Ownable.sol	100	100	100	100	
Pausable.sol	100	87.5	100	100	
Proxyable.sol	100	100	100	100	
UpgradeabilityBeaconProxy.sol	71.43	33.33	83.33	75	15,20
UpgradeabilityProxy.sol	85.71	50	100	87.5	15
UpgradeableBeacon.sol	100	50	100	100	
All files	96.47	87.69	94.84	96.46	

Changelog

- 2024-03-27 - Initial report
- 2024-03-29 - Final report

About Quantstamp

Quantstamp is a global leader in blockchain security. Founded in 2017, Quantstamp's mission is to securely onboard the next billion users to Web3 through its best-in-class Web3 security products and services.

Quantstamp's team consists of cybersecurity experts hailing from globally recognized organizations including Microsoft, AWS, BMW, Meta, and the Ethereum Foundation. Quantstamp engineers hold PhDs or advanced computer science degrees, with decades of combined experience in formal verification, static analysis, blockchain audits, penetration testing, and original leading-edge research.

To date, Quantstamp has performed more than 500 audits and secured over $200 billion in digital asset risk from hackers. Quantstamp has worked with a diverse range of customers, including startups, category leaders and financial institutions. Brands that Quantstamp has worked with include Ethereum 2.0, Binance, Visa, PayPal, Polygon, Avalanche, Curve, Solana, Compound, Lido, MakerDAO, Arbitrum, OpenSea and the World Economic Forum.

Quantstamp's collaborations and partnerships showcase our commitment to world-class research, development and security. We're honored to work with some of the top names in the industry and proud to secure the future of web3.

Notable Collaborations & Customers:

- Blockchains: Ethereum 2.0, Near, Flow, Avalanche, Solana, Cardano, Binance Smart Chain, Hedera Hashgraph, Tezos
- DeFi: Curve, Compound, Maker, Lido, Polygon, Arbitrum, SushiSwap
- NFT: OpenSea, Parallel, Dapper Labs, Decentraland, Sandbox, Axie Infinity, Illuvium, NBA Top Shot, Zora
- Academic institutions: National University of Singapore, MIT

Quantstamp