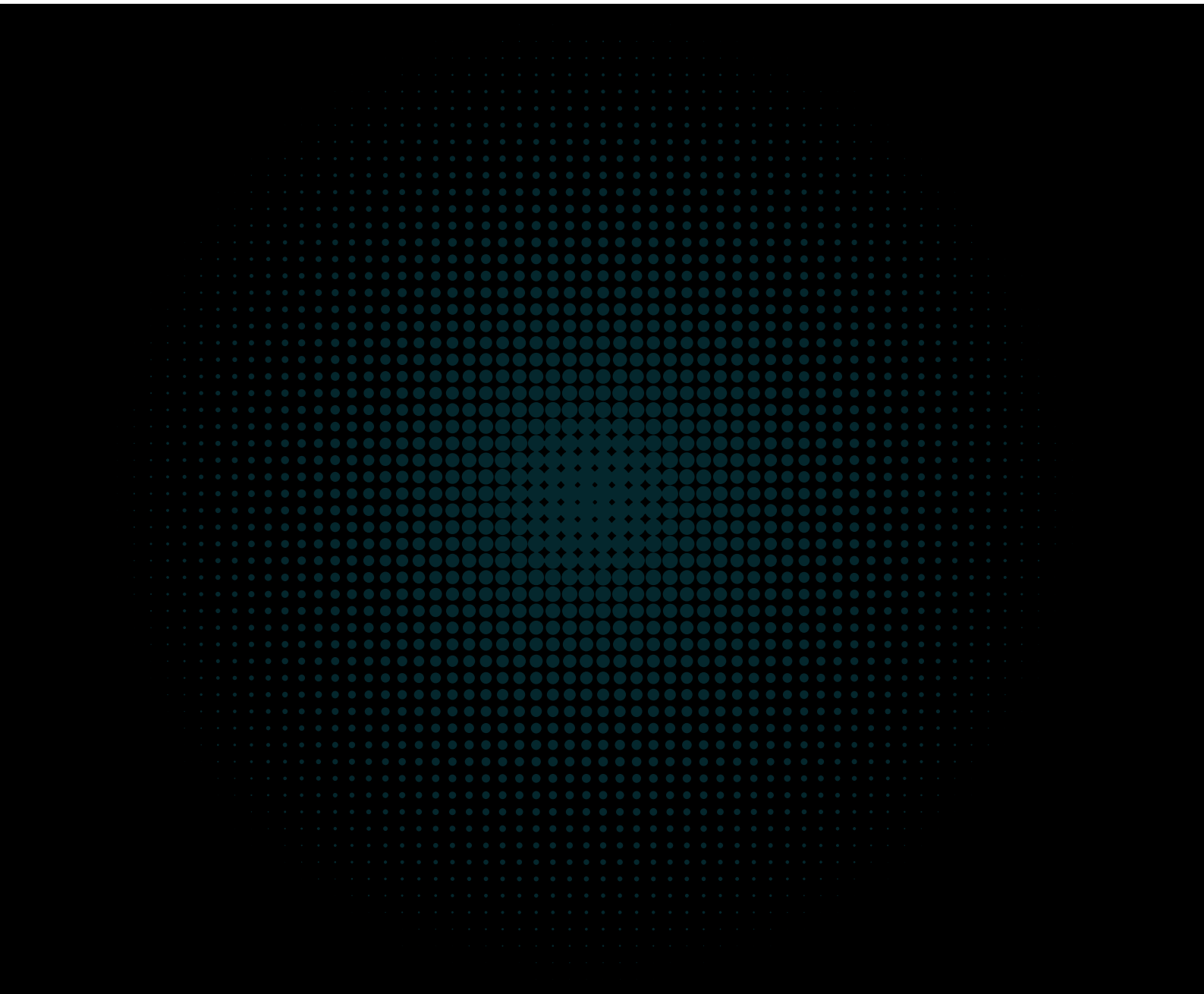
cmta.

CMTAT Solana Specification

Functional specifications of the CMTAT on Solana.

CMTAT Solana version: v1.0.0
First published: November 2025



CMTAT Solana

This document contains the guidelines to deploy a CMTAT compliant token on Solana.

CMTAT

- The CMTA Standard Token for Securities (CMTAT) is an open standard for smart contracts designed specifically for the tokenization of financial instruments such as equity, debt and structured products and other transferable securities.
- CMTAT is blockchain agnostic in that it defines a set of functionalities that a security token should implement.

CMTAT specifications are available on CMTA website: cmta.ch/standards/cmta-token-cmtat

Solana

- Solana is a high-performance, Layer 1 blockchain optimized for finance and internet capital markets.
- Solana enables parallel execution and deterministic finality natively on its base layer, ensuring high throughput without sacrificing user experience or composability.

See What is Solana, Solana - tokenized equities

Solana introduction

Tokens on Solana are digital assets that represent ownership over diverse categories of assets. Tokenization enables the digitalization of property rights.

Tokens on Solana are referred to as SPL (Solana Program Library) Tokens.

Solana Token

This program defines a common implementation for Fungible and Non Fungible tokens.

Key Points

- Token Programs contain all instruction logic for interacting with tokens on the network (both fungible and non-fungible).
- A Mint Account represents a specific token and stores global metadata about the token such as the total supply and mint authority (address authorized to create new units of a token).

- A Token Account tracks individual ownership of tokens for a specific mint account for a specific owner.
- An Associated Token Account is a Token Account created with an address derived from the owner and mint account addresses.

Features

- Create a Token Mint – Initialize a new SPL Token mint.
- Create a Token Account – Open an account to hold SPL tokens.
- Mint Tokens – Generate new units of the token and assign them to an account.
- Transfer Tokens – Send tokens between accounts securely.
- Approve Delegate – Grant another account permission to manage tokens on behalf of the owner.
- Revoke Delegate – Remove delegate permissions from an account.
- Set Authority – Change the authority for a mint or token account (e.g., minting, freezing, account management).
- Burn Tokens – Permanently destroy tokens, reducing supply.
- Sync Native – Wrap native SOL into wrapped SOL (WSOL) for token program compatibility.
- Close Token Account – Close an SPL Token account and reclaim its SOL rent.
- Freeze Account – Halt activity on a token account.
- Thaw Account – Reactivate a previously frozen token account.

Solana Extension (Token-2022)

The Token-2022 Program, also known as Token Extensions, is a superset of the functionality provided by the Token Program.

Token extensions introduce a new set of ways to extend the normal token functionality.

- The original Token program brought the basic capabilities of minting, transferring and freezing tokens.
- The Token Extensions program includes the same features, but comes come with additional features such as permanent delegate, custom transfer logic, extended metadata, and much more.
- The Token Extensions program has the programID `TokenzQdBNbLqP5VEhdkAS6EPFLC1PHnBqCXEpPxuEb` and is a superset of the original functionality provided by the Token Program at `TokenkegQfeZyiNwAJbNbGKPFXCWuBvf9Ss623VQ5DA`.

The full list of available extensions on the Solana Token-2022 program is below:

Mint extensions

Mint extensions currently include:

- transfer fees
- closing mint
- interest-bearing tokens
- non-transferable tokens
- permanent delegate
- transfer hook
- metadata pointer
- metadata

- group pointer
- group
- group member pointer
- group member
- scaled UI amount
- pausable
- confidential transfers
- confidential mint-burn

Account extensions

Account extensions currently include:

- memo required on incoming transfers
- immutable ownership
- default account state
- CPI guard

CMTAT - Solana Requirements

Comparison tab

This section contains four tables to indicate if a Solana token feature or an extension is required or optional to align with the by CMTAT framework's required or optional features.

CMTAT framework -> Solana token (Basic/Extension)

In the below table, the CMTAT framework required features are mapped to Solana token features.

CMTAT framework mandatory functionalities	**Solana token basic features**	**Solana Extension**	**CMTAT Solidity corresponding features**
Know total supply	Query the Mint Account	☒	ERC20 `totalSupply`
Know balance	Query the Token Account	☒	ERC20 `balanceOf`
Transfer tokens	Transfer tokens	☒	ERC20 `transfer`
Create tokens (mint)	Mint tokens	☒	`Mint/batchMint`
Cancel tokens (force burn)	☒	Permanent Delegate	`burn/batchBurn`

CMTAT framework mandatory functionalities	Solana token basic features	Solana Extension	CMTAT Solidity corresponding features
Pause tokens	☒	Pausable (*pause*) (*Nb. During this time, it is normally not possible to transfer, mint or burn tokens.) To enable mint and burn during pause a transfer hook must be used. See here.*	Pause (*Nb. With CMTAT Solidity it is still possible to burn and mint while transfers are paused.)*
Unpause tokens	☒	Pausable (*resume*)	`unpause`
Deactivate contract	☒	Mint Close Authority (Burn all tokens, close Mint Account, eventually revoke authorities)	`deactivateContract`
Freeze	Freeze Account	☒	`setAddressFrozen` (previously `freeze`)
Unfreeze	Thaw Account	☒	`setAddressFrozen` (previously `unfreeze`)
Name attribute	☒	Metadata, Metadata Pointer	ERC20 `name` attribute
Ticker symbol attribute	☒	Metadata, Metadata Pointer	ERC20 `symbol` attribute
Token ID attribute	☒	Metadata, Metadata Pointer	`tokenId`
Reference to legally required documentation	☒	Metadata, Metadata Pointer	`terms`

CMTAT extended -> Solana token (Basic/Extension)

In the below table, the CMTAT framework optional features are mapped to Solana token features.

CMTAT Functionalities	Solana token basic features	Solana Extension	CMTAT Solidity corresponding features
force Transfer	☒	Permanent Delegate	`forcedTransfer`
freeze partial token	☒	☒	`freezePartialTokens` / `unfreezePartialTokens`

CMTAT Functionalities	Solana token basic features	Solana Extension	CMTAT Solidity corresponding features
Whitelisting	☒	Default Account State	CMTAT Allowlist / CMTAT with rule whitelist
RuleEngine / transfer hook	☒	Transfer Hook (not compatible with Confidential Transfer)	CMTAT with RuleEngine
On-chain snapshot	☒	☒	SnapshotEngine or dedicated deployment version
Upgradibility	N/A	N/A	CMTAT Upgradeable version
Feepayer/gasless	N/A See Sponsoring Solana transactions - Coinbase Developer Documentation It is managed at the transaction level, no link with the token.	N/A	CMTAT with ERC-2771 module

Solana token basic -> CMTAT

In the below table, the Solana token basic features are mapped to the CMTAT framework.

Solana Token features	Description	Solana CMTAT Required	CMTAT Required	CMTAT optional	CMTAT corresponding features	Note
Create a Token Mint	A mint account uniquely represents a token on Solana and stores its global metadata.	☑	N/A	N/A	N/A	Correspond to deploy the smart contract on EVM chain
Create a Token Account	A token account stores your balance of a specific token.	☑	N/A	N/A	N/A	No relevant for EVM based blockchain
Mint Tokens	Minting creates new units of a token using the `MintTo` instruction.	☑	☑	☒	mint/batchMint	
Transfer Tokens	Token transfers move tokens between token accounts of the same mint.	☑	☑	☒	ERC20 transfer	

Solana Token features	Description	Solana CMTAT Required	CMTAT Required	CMTAT optional	CMTAT corresponding features	Note
Approve Delegate	The `ApproveChecked` instruction grants another account (the delegate) permission to transfer a specific amount of tokens from your token account.	☑	☑	☒	ERC-20 approve	
Revoke Delegate	The `Revoke` instruction removes all transfer permissions from the currently approved delegate.	☑	☑	☒	ERC-20 approve	
Set Authority	The `SetAuthority` instruction changes or revokes authorities on mints and token accounts.	☑	☑	☒	`RBAC system` `grantRole`	
Burn Tokens	The `BurnChecked` instruction permanently destroys tokens by reducing the balance in a token account.	☑	☒	☑	`burnFrom`	
Sync Native	The `SyncNative` instruction synchronizes a wrapped SOL (WSOL) token account balance with the actual SOL (lamports) stored in it.	☒	☒	☒	☒	
Close Token Account	The `CloseAccount` instruction permanently closes a token account and transfers all remaining SOL (rent) to a specified destination account.	☑	☒	☒	☒	Solana specific features (but relevant to implement)
Freeze Account	The `FreezeAccount` instruction prevents all token transfers or token burns from a specific token account.	☑	☑	☒	`setAddressFrozen`(prev. `freeze`)	
Thaw Account	The `ThawAccount` instruction reverses a freeze, restoring full functionality to a previously frozen token account.	☑	☑	☒	`setAddressFrozen`(prev. `unfreeze`)	

Solana extensions -> CMTAT

In the below table, the Solana extension features are mapped to the CMTAT framework.

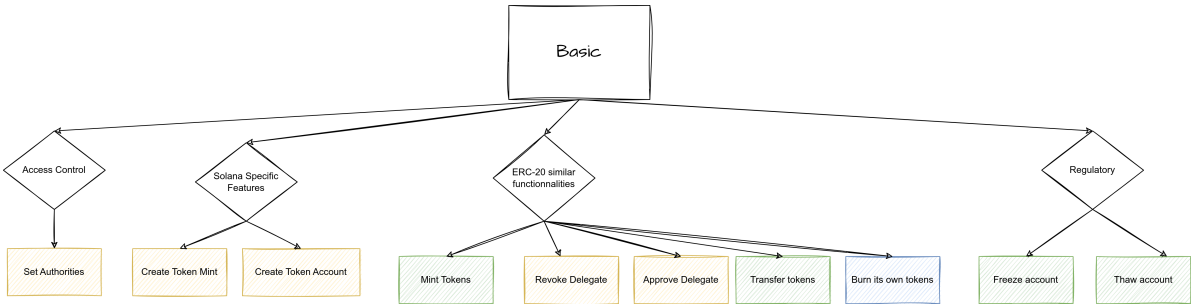
Solana Extension	Description	CMTAT Required (Core features)	CMTAT optional	CMTAT Solidity corresponding features
Mint Close Authority	Close mint account	☑	☒	`deactivateContract`
Transfer Fees	Transferring tokens with a transfer fee	☒	☒	☒
Default Account State	Force all new token accounts to be frozen.	☒	☑	CMTAT Allowlist / CMTAT with rule whitelist
Immutable Owner	Impossible to reassign ownership of an account.	☒	☒	☒
Non-Transferable Tokens	Allows for "soul-bound" tokens that cannot be moved to any other entity.	☒	☒	☒
Required Memo on Transfer	Enforces that all incoming transfers must have an accompanying memo instruction right before the transfer instruction.	☒	☑	CMTAT ERC-1363
Interest-Bearing Tokens	Using the `InterestBearingMint` extension and the `amount_to_ui_amount` instruction, you can set an interest rate on your token and fetch its amount with interest at any time.	☒	☒	☒
Permanent Delegate	Allows to specify a permanent account delegate for a mint. This authority can burn or transfer any amount of tokens.	☒	☑	Forced transfer
CPI Guard	CPI Guard is an extension that prohibits certain actions inside cross-program invocations.	☒	☒	N/A (Solana specific extension)

Solana Extension	Description	CMTAT Required (Core features)	CMTAT optional	CMTAT Solidity corresponding features
Transfer Hook	The Transfer Hook Interface is designed to allow token creators to "hook" additional functionality into token transfers.	☒	☑	CMTAT with RuleEngine
Metadata Pointer	Allows a token creator to designate an address that describes the canonical metadata.	☑	☒	N/A
Metadata	Allows a mint creator to include their token's metadata directly in the mint account.	☑	☒	ERC20 name & symbol terms attributes (uri, hash)
Group Pointer	Allows a token creator to designate a group account that describes the mint.	☒	☒	☒
Group	Token-2022 supports grouping of tokens through the group extension.	☒	☒	☒
Member Pointer	The member pointer allows a token creator to designate a member account that describes the mint.	☒	☒	☒
Member	The configurations for a member (group address and the member's number) mcan be stored directly in the mint itself.	☒	☒	☒
Pausable	"Pause" all activity. During this time, it is not possible transfer, mint, or burn tokens.	☑	☒	`pause` With CMTAT Solidity, it is possible to burn and mint while transfers are paused.
Scaled UI Amount	Change how the UI amount of tokens are represented	☒	☒	☒

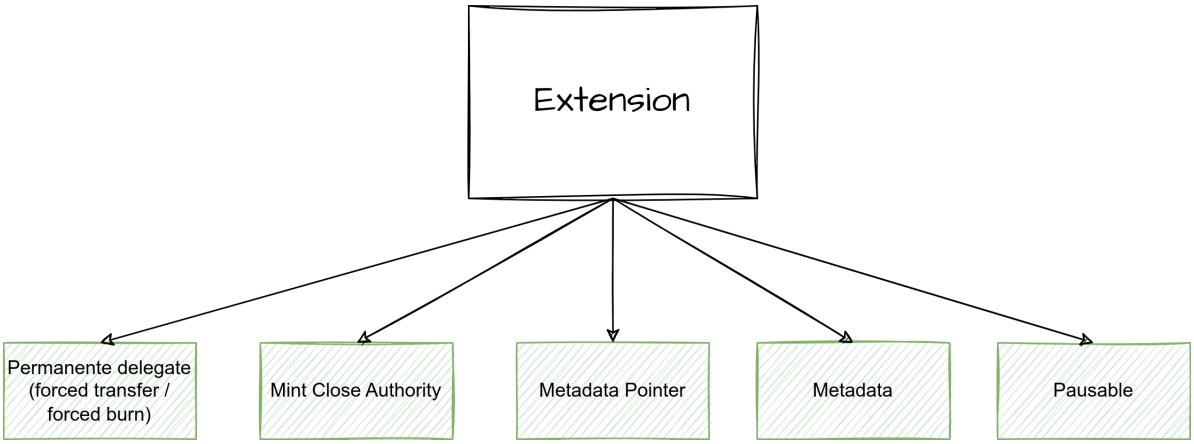
Schema

Features

Base

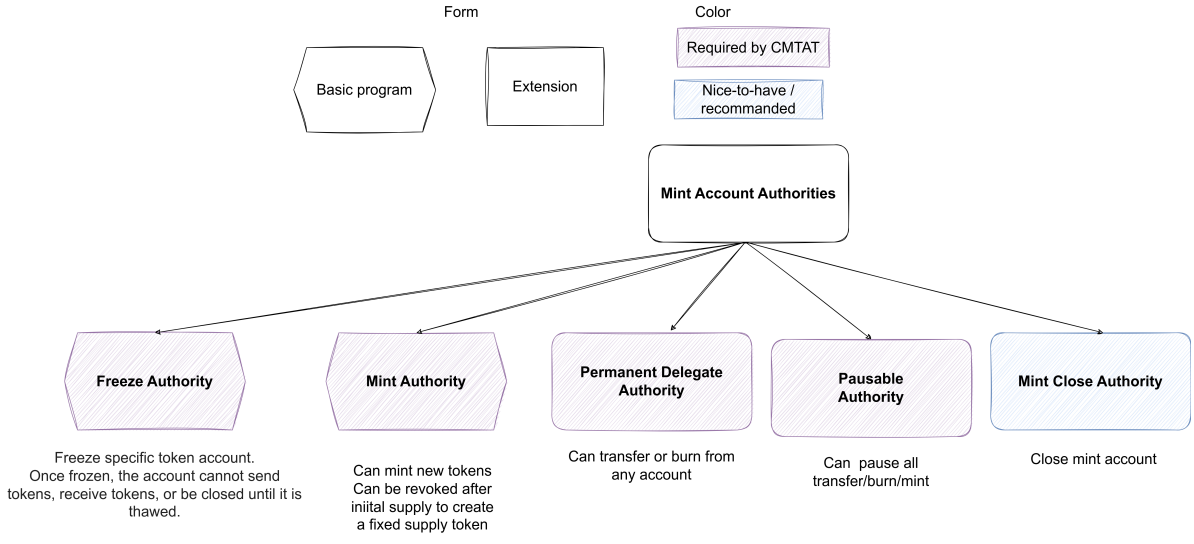


Extensions



Access Control

Here is a schema representing the different authorities:



Main difference with EVM Solidity version

The CMTAT version for Ethereum and EVM-compatible blockchains is also available on GitHub CMTA/CMTAT.

burn / transfer

- With Solana, there is no difference between a regular transfer and a forced transfer, while on Ethereum it is two distinct functions. Same applies to a force burn.
    - Nevertheless, the signer of the transaction will be different if it is a forced transfer (delegate authority) or a regular transfer (token holder signer).
- Forced transfer is an optional feature of CMTAT. While the EVM version allows to only include the force burn, with Solana, it is not possible to include the force burn without the force transfer.
    - It is possible to separate force burn from force transfer if the permanent delegate is itself a smart contract that would only allow for one of the two options.
- Contrary to the Solidity version, token holder can burn by default their own tokens.

Access control

- With the Solidity version, you can have a super admin which delegates several tasks to different addresses through different roles, for example the minter role to mint tokens.
- With Solana, you can also delegate roles, but it is not possible to delegate them while keeping a super admin.

Note: Similar to forced transfer above, if the role authorities are themselves smart contracts you can create complex control structures with multisigs, admin accounts etc. In order to have a super admin, you can designate all roles to one smart contract which then has its own rules as to who has authority over which role.

Mint/burn while pause

- With Ethereum, you can still burn and mint tokens while pausing regular transfers.
- This is not the case with Solana where the pause will also apply to mint and burn operations in addition to regular transfers.

Note: In order to enable this, you can use a transfer hook that is set to a program that just fails every transfer. This way you retain all other administrative features but prevent anyone from transferring tokens.

CMTAT Deployment Guide (Token-2022)

This guide includes the deployment of a token on Solana which respects the CMTAT specification and contains the following features

- Mint tokens
- Freeze/unfreeze accounts
- Burn and forced transfer (Permanent Delegate)
- Pause/resume token activity
- Token information
    - Token name and Symbol
    - On-chain metadata with custom fields (`termsHash`, jurisdiction, issuer)
- Deactivate the token
    - close mint

All the operations have been made on a Linux machine through the SPL command line on a local Solana blockchain

Set up

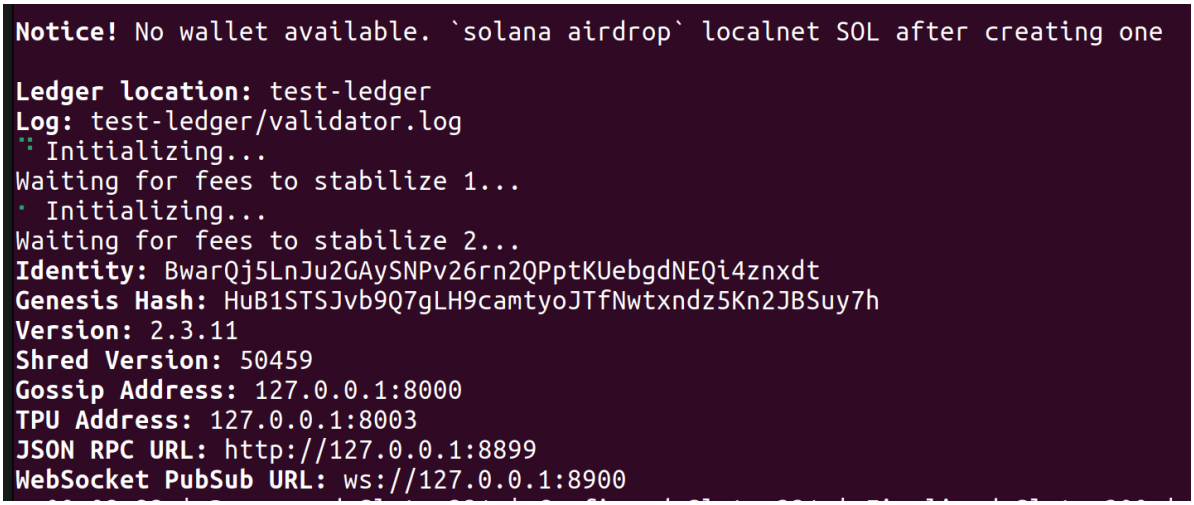
Environment variable

To simplify command, different values are stored in the current bash session environment.

Variable	Description	Value
ADMIN_SOLANA_KEYPAIR	Path to the JSON file containing the admin keypair	Public Address `Annh1c8T1nLKqU1dNNm7xUho7H6hU9KV6JE9THndHEfj`
USER_SOLANA_KEYPAIR	Path to the JSON file containing the user keypair	Public address `9Grr8jKaZUji1VGj3uBBE3vWBmRbf48CGUchAUfxrqk`
TOKEN_MINT	Token address	`JA6iL96LYav6GaMS1NnrZRTYA98PjfyQyu9DBwxdb2b2`
ADMIN_TOKEN_ACCOUNT	Admin Token account for the corresponding TOKEN_MINT	`ApXcDVWCXhPgfAmUYqQ85JcYmyxqecqDPKXPz8B2fjqK`
USER_TOKEN_ACCOUNT	User Token account for the corresponding TOKEN_MINT	`diZa8NKEJ7wTf31meXA9X2pyQnBsTnV4jsYUmwfFAK1`

Run a local blockchain

```
solana-test-validator
```



Generate Admin Keypair

This keypair will act as the mint authority, freeze authority, pause authority, and update authority for your token.

> **Important:** The following command generates a new keypair for demonstration/example purposes.
> Do not use this keypair in production, as it is stored locally and not secured in a hardware wallet or secure key management system. For production, use a **secure key management solution** (e.g., hardware wallet, secure enclave, or custodian service).

```
# Generate a new Solana keypair for admin authority
solana-keygen new -o test_admin.json
# Export environment variable to use this keypair with SPL commands export
export ADMIN_SOLANA_KEYPAIR=test_admin.json
# Generate a new Solana keypair for a test user
solana-keygen new -o test_user.json
# Export environment variable to use this keypair with SPL commands
export USER_SOLANA_KEYPAIR=test_user.json

# Change the signer in the config for the admin solana config
solana config set -k $ADMIN_SOLANA_KEYPAIR
# Check configuration
solana config get
# Check default address
solana address --keypair $ADMIN_SOLANA_KEYPAIR
solana address

#Change url to local blockchain/validator
solana config set --url http://127.0.0.1:8899

#Aidrop SOL token to pay gas fees locally
solana airdrop 1000 $USER_SOLANA_KEYPAIR
solana airdrop 1000 $ADMIN_SOLANA_KEYPAIR
```

- `test_admin.json` is the local file storing the token admin keypair.
- `test_user.json` is the local file storing the test user (token holder) keypair.
- `SOLANA_KEYPAIR` environment variable allows CLI tools (like `spl-token`) to reference it automatically.

Create Token with the required extensions

```
spl-token create-token \  --program-id
TokenzQdBNbLqP5VEhdkAS6EPFLC1PHnBqCXEpPxuEb \  --decimals  <decimals>\  --mint-
authority < Solana Keypair> \  --enable-permanent-delegate \  --enable-pause \
 --enable-close \  --enable-metadata  --enable-freeze
```

Note

- `TokenzQdBNbLqP5VEhdkAS6EPFLC1PHnBqCXEpPxuEb` is the programId of the Token Extensions program. See Getting Started with Token Extensions
- `decimals`: as part of CMTA specification, decimal numbers must be set to zero (which means that the tokens admit no fractional parts), unless the law governing the tokenized security allows the transfer of fractions.
- You can decide to use a different keypair address for the `mint-authority`

- At deployment, the command-line does not allow you to set a different key for the other authorities (`freeze`, `pause`, `delegate`)

Example

Command

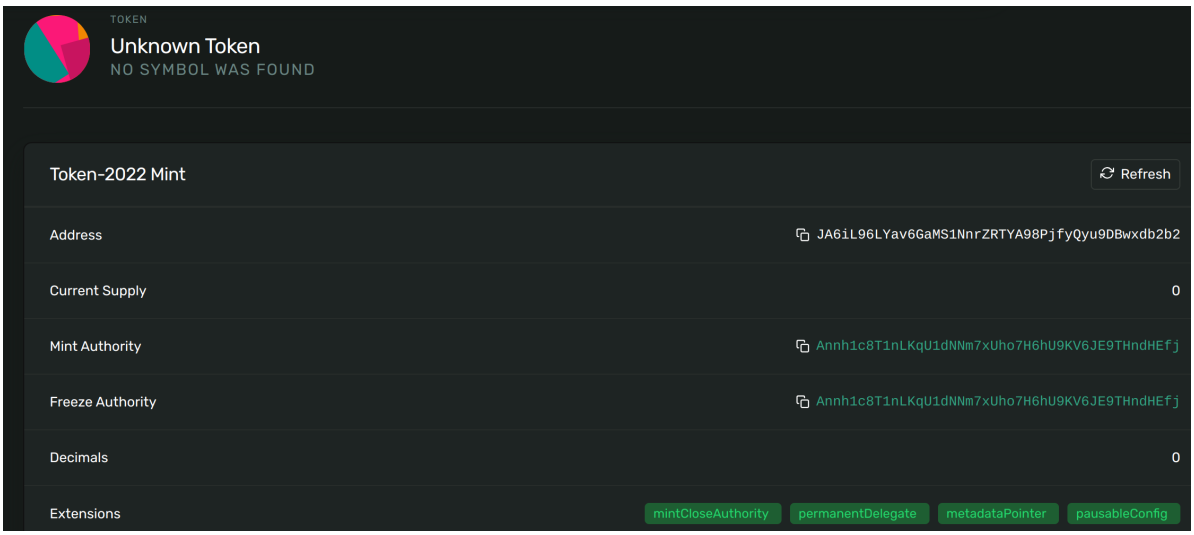
```
spl-token create-token --program-id TokenzQdBNbLqP5VEhdkAS6EPFLC1PHnBqCXEpPxuEb --decimals 0 --mint-authority $ADMIN_SOLANA_KEYPAIR --enable-permanent-delegate --enable-pause --enable-close --enable-metadata --enable-freeze
```

Result

> Creating token JA6iL96LYav6GaMS1NnrZRTYA98PjfyQyu9DBwxdb2b2 under program TokenzQdBNbLqP5VEhdkAS6EPFLC1PHnBqCXEpPxuEb
> To initialize metadata inside the mint, please run `spl-token initialize-metadata JA6iL96LYav6GaMS1NnrZRTYA98PjfyQyu9DBwxdb2b2 <YOUR_TOKEN_NAME> <YOUR_TOKEN_SYMBOL> <YOUR_TOKEN_URI>`, and sign with the mint authority.
>
> Address: JA6iL96LYav6GaMS1NnrZRTYA98PjfyQyu9DBwxdb2b2
> Decimals: 0

Save the mint address as `TOKEN_MINT`.

```
export TOKEN_MINT=JA6iL96LYav6GaMS1NnrZRTYA98PjfyQyu9DBwxdb2b2
```



Verification

```
spl-token display [OPTIONS] <TOKEN_ADDRESS>
```

```
spl-token display $TOKEN_MINT
```

Result

> SPL Token Mint
> Address: JA6iL96LYav6GaMS1NnrZRTYA98PjfyQyu9DBwxdb2b2
> Program: TokenzQdBNbLqP5VEhdkAS6EPFLC1PHnBqCXEpPxuEb
> Supply: 0
> Decimals: 0
> Mint authority: Annh1c8T1nLKqU1dNNm7xUho7H6hU9KV6JE9THndHEfj
> Freeze authority: Annh1c8T1nLKqU1dNNm7xUho7H6hU9KV6JE9THndHEfj
> Extensions
> Close authority: Annh1c8T1nLKqU1dNNm7xUho7H6hU9KV6JE9THndHEfj
> Permanent delegate: Annh1c8T1nLKqU1dNNm7xUho7H6hU9KV6JE9THndHEfj
> Metadata Pointer:
> Authority: Annh1c8T1nLKqU1dNNm7xUho7H6hU9KV6JE9THndHEfj
> Metadata address: JA6iL96LYav6GaMS1NnrZRTYA98PjfyQyu9DBwxdb2b2

Initialize On-Chain Metadata

```
spl-token initialize-metadata --url <url> \ --program-2022 --mint-authority <Solana Keypair> \ --update-authority <Solana Keypair> <name> <symbol> <Token URI>
```

Note

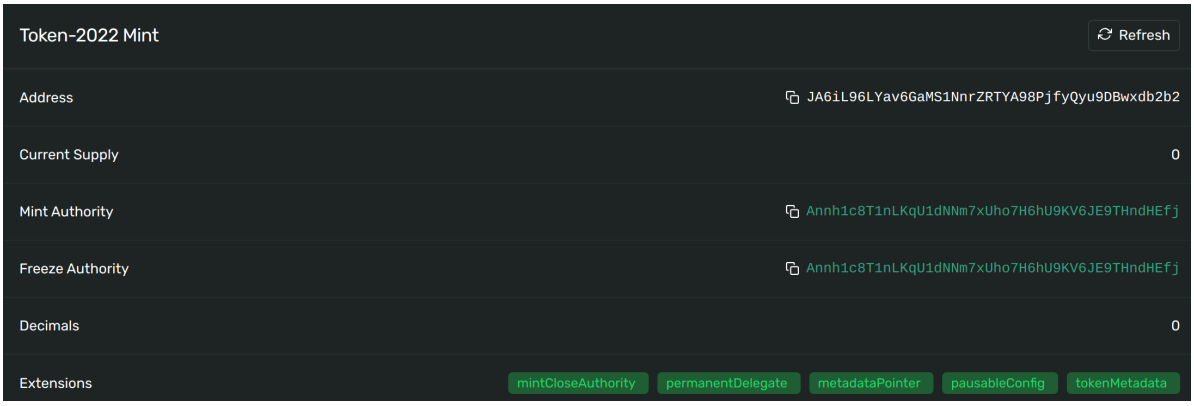
- The CMTA specification only includes the token name, symbol and the terms uri (if relevant)
- Terms uri: Reference to any legally required documentation about the distributed ledger or the smart contract, such as the tokenization terms, the terms of the instrument and other relevant documents (e.g. prospectus or key information document).
- Token-2022 Metadata Structure. See Token metadata

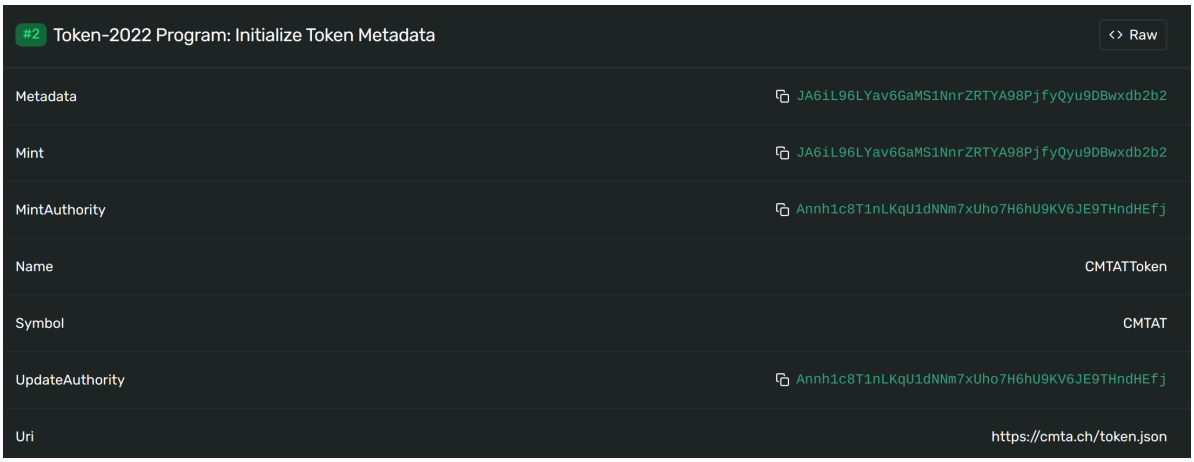
Field	Type	Description	Example
`update_authority`	`OptionalNonZeroPubkey`	Public key allowed to update metadata. If unset, metadata is immutable.	`7gH…kP1`
`mint`	`Pubkey`	The mint address this metadata belongs to (prevents spoofing).	`<address>`
`name`	`String`	Human-readable name of the token.	`CMTAT Token`
`symbol`	`String`	Short token symbol (≤10 chars).	`CMTAT`

Field	Type	Description	Example
`uri`	`String`	URI pointing to extended metadata or compliance docs (e.g. JSON file, website).	`https://cmta.ch/token.json`
`additional_metadata`	`Vec<(String, String)>`	Flexible key–value pairs for extra fields such as compliance info, issuer, or terms hash.	`("termsHash","Qm123…")`

Example

```
spl-token initialize-metadata --program-2022 --mint-authority
$ADMIN_SOLANA_KEYPAIR --update-authority $ADMIN_SOLANA_KEYPAIR $TOKEN_MINT
CMTATToken CMTAT https://cmta.ch/token.json
```





Verification

```
spl-token display $TOKEN_MINT
```

> SPL Token Mint
> Address: JA6iL96LYav6GaMS1NnrZRTYA98PjfyQyu9DBwxdb2b2
> Program: TokenzQdBNbLqP5VEhdkAS6EPFLC1PHnBqCXEpPxuEb
> Supply: 0
> Decimals: 0
> Mint authority: Annh1c8T1nLKqU1dNNm7xUho7H6hU9KV6JE9THndHEfj
> Freeze authority: Annh1c8T1nLKqU1dNNm7xUho7H6hU9KV6JE9THndHEfj
> Extensions
> Close authority: Annh1c8T1nLKqU1dNNm7xUho7H6hU9KV6JE9THndHEfj
> Permanent delegate: Annh1c8T1nLKqU1dNNm7xUho7H6hU9KV6JE9THndHEfj
> Metadata Pointer:
> Authority: Annh1c8T1nLKqU1dNNm7xUho7H6hU9KV6JE9THndHEfj
> Metadata address: JA6iL96LYav6GaMS1NnrZRTYA98PjfyQyu9DBwxdb2b2
> Metadata:
> Update Authority: Annh1c8T1nLKqU1dNNm7xUho7H6hU9KV6JE9THndHEfj
> Mint: JA6iL96LYav6GaMS1NnrZRTYA98PjfyQyu9DBwxdb2b2
> Name: CMTATToken
> Symbol: CMTAT
> URI: https://cmta.ch/token.json

Create Token Account

```
spl-token create-account [OPTIONS] <TOKEN_MINT_ADDRESS> [ACCOUNT_KEYPAIR]
```

Options

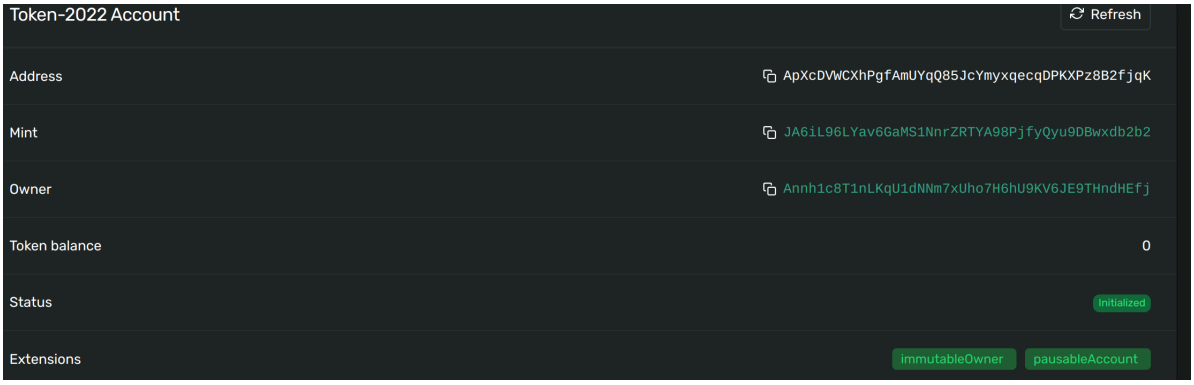
--program-2022
: Use token extension program token 2022 with program id: TokenzQdBNbLqP5VEhdkAS6EPFLC1PHnBqCXEpPxuEb

--owner <OWNER_ADDRESS>
: Address of the primary authority controlling a mint or account. Defaults to the client keypair address.

Admin

Create the token account for the admin

```
spl-token create-account --program-2022 $TOKEN_MINT --owner
$ADMIN_SOLANA_KEYPAIR
```



Result

> Creating account ApXcDVWCXhPgfAmUYqQ85JcYmyxqecqDPKXPz8B2fjqK

We export the token account created in an environment variable:

```
export ADMIN_TOKEN_ACCOUNT=ApXcDVWCXhPgfAmUYqQ85JcYmyxqecqDPKXPz8B2fjqK
```

User

Create a user token account

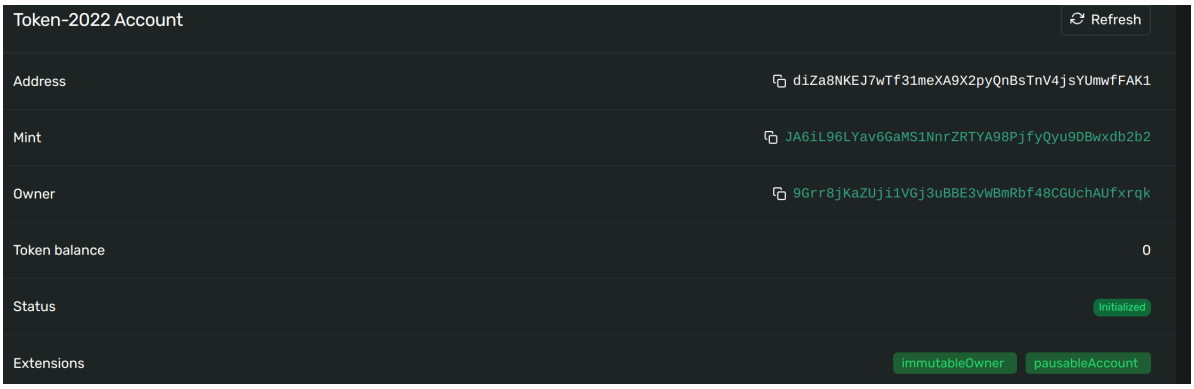
```
# Change default key to USER
solana config set -k $USER_SOLANA_KEYPAIR
# Create account
spl-token create-account --program-2022 $TOKEN_MINT --owner
$USER_SOLANA_KEYPAIR
#rollback change
solana config set -k $ADMIN_SOLANA_KEYPAIR
```

Result:

> Creating account diZa8NKEJ7wTf31meXA9X2pyQnBsTnV4jsYUmwfFAK1

We export the token account created in an environment variable:

```
export USER_TOKEN_ACCOUNT=diZa8NKEJ7wTf31meXA9X2pyQnBsTnV4jsYUmwfFAK1
```



Mint Initial Supply

```
spl-token mint [OPTIONS] <TOKEN_MINT_ADDRESS> <TOKEN_AMOUNT> [--]
[RECIPIENT_TOKEN_ACCOUNT_ADDRESS]
```

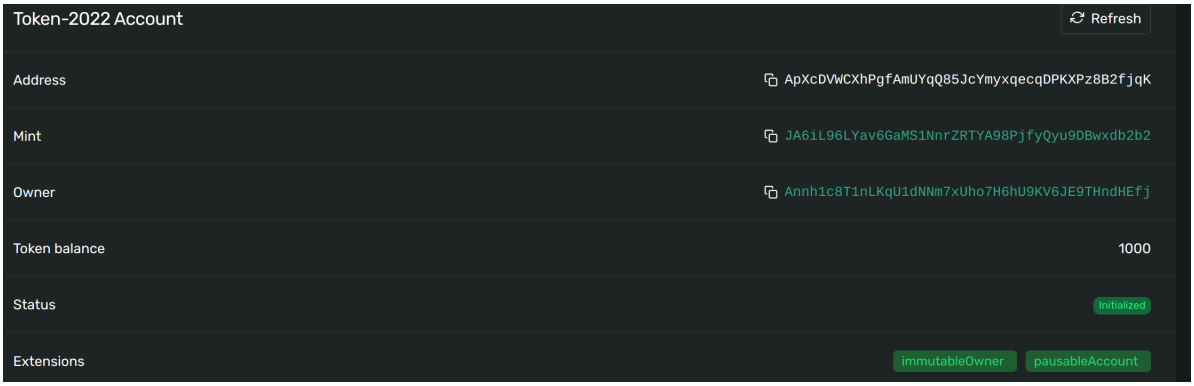
Example

Admin

```
spl-token mint  --program-2022 --mint-authority $ADMIN_SOLANA_KEYPAIR
$TOKEN_MINT 1000 $ADMIN_TOKEN_ACCOUNT
```

Result

> Minting 1000 tokens
> Token: JA6iL96LYav6GaMS1NnrZRTYA98PjfyQyu9DBwxdb2b2
> Recipient: ApXcDVWCXhPgfAmUYqQ85JcYmyxqecqDPKXPz8B2fjqK

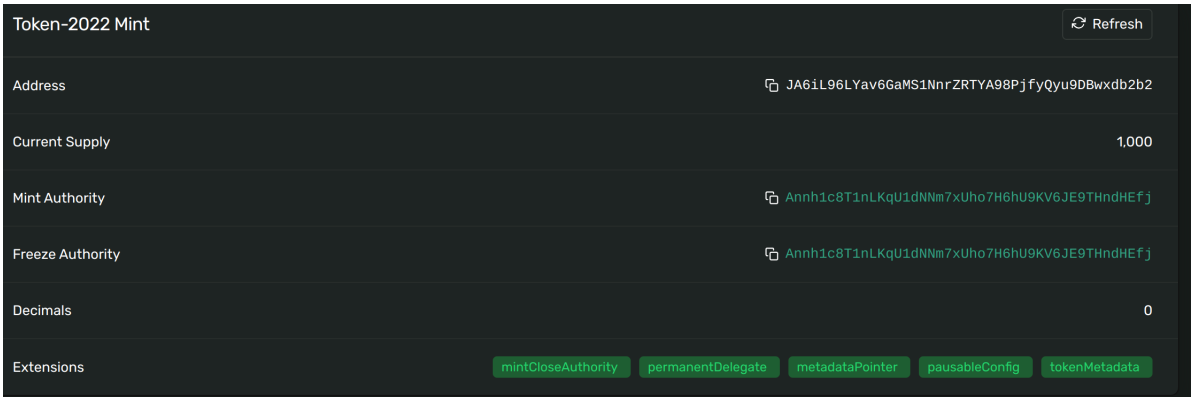


Verification

- Check the supply

```
spl-token supply $TOKEN_MINT
```

Result: `1000`



- Check the token account balance

```
spl-token balance [OPTIONS] [TOKEN_MINT_ADDRESS]
```

```
spl-token balance --program-2022 --address $ADMIN_TOKEN_ACCOUNT
```

Result: `1000`

User

```
spl-token mint --program-2022 --mint-authority $ADMIN_SOLANA_KEYPAIR
$TOKEN_MINT 300 $USER_TOKEN_ACCOUNT
```

Result

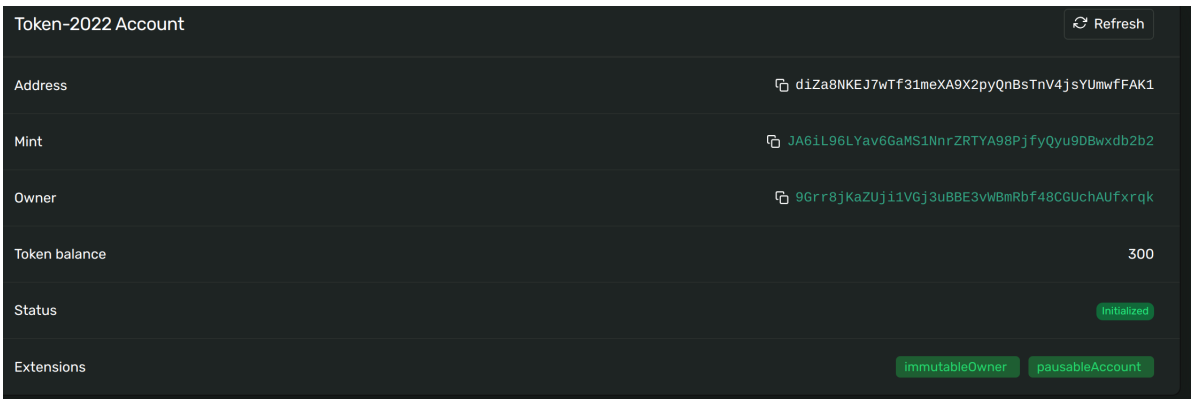
> Minting 300 tokens
> Token: JA6iL96LYav6GaMS1NnrZRTYA98PjfyQyu9DBwxdb2b2
> Recipient: diZa8NKEJ7wTf31meXA9X2pyQnBsTnV4jsYUmwfFAK1

```
spl-token balance --program-2022 --address $USER_TOKEN_ACCOUNT
```

Result: 300

```
spl-token supply $TOKEN_MINT
```

Result: 1300



Freeze / Unfreeze Accounts

The Mint may also contain a `freeze_authority` which can be used to issue `FreezeAccount` instructions that will render an Account unusable.

- Token instructions that include a frozen account will fail until the Account is thawed using the `ThawAccount` instruction.
- The `SetAuthority` instruction can be used to change a Mint's `freeze_authority`.
- If a Mint's `freeze_authority` is set to `None` then account freezing and thawing is permanently disabled and all currently frozen accounts will also stay frozen permanently.

```
spl-token freeze [OPTIONS] <TOKEN_ACCOUNT_ADDRESS>
spl-token thaw [OPTIONS] <TOKEN_ACCOUNT_ADDRESS>
```

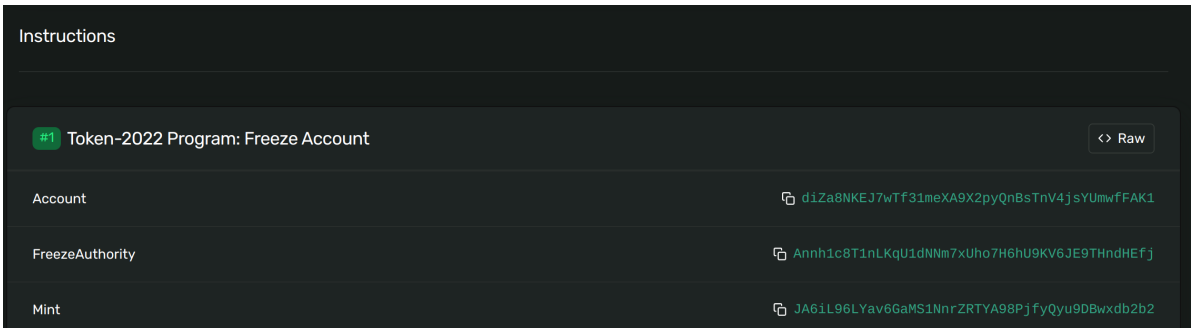
Freeze

```
spl-token freeze --freeze-authority $ADMIN_SOLANA_KEYPAIR $USER_TOKEN_ACCOUNT
```

Result

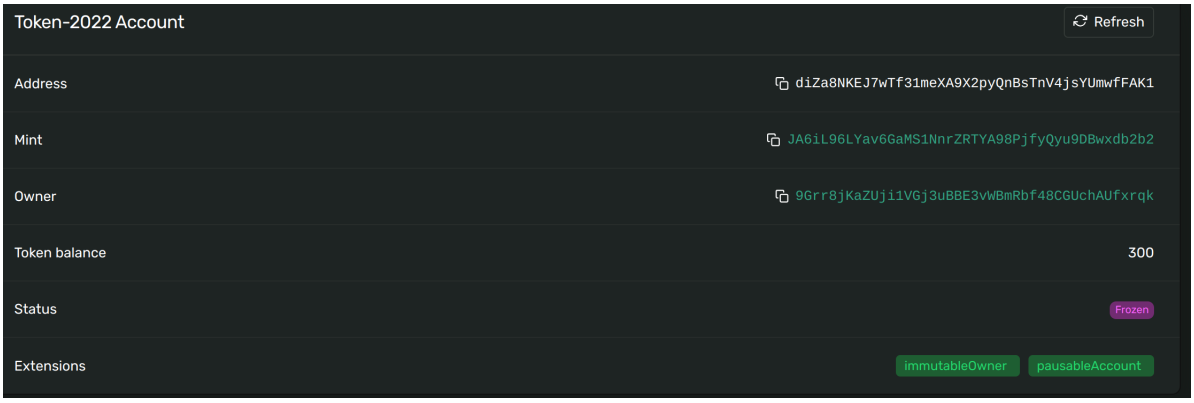
> Freezing account: diZa8NKEJ7wTf31meXA9X2pyQnBsTnV4jsYUmwfFAK1
> Token: JA6iL96LYav6GaMS1NnrZRTYA98PjfyQyu9DBwxdb2b2

- Instructions



- Account status

We can see that the status is passed to `Frozen`.



Transfer

```
spl-token transfer [OPTIONS] \ <TOKEN_MINT_ADDRESS> <TOKEN_AMOUNT> \
<RECIPIENT_WALLET_ADDRESS or RECIPIENT_TOKEN_ACCOUNT_ADDRESS>
```

Example

We try to transfer tokens from our user account to the admin account

```
solana config set -k $USER_SOLANA_KEYPAIR
spl-token transfer --program-2022 --from $USER_TOKEN_ACCOUNT $TOKEN_MINT 100
$ADMIN_TOKEN_ACCOUNT
```

Result

> Transfer 100 tokens
> Sender: diZa8NKEJ7wTf31meXA9X2pyQnBsTnV4jsYUmwfFAK1
> Recipient: ApXcDVWCXhPgfAmUYqQ85JcYmyxqecqDPKXPz8B2fjqK
> Error: Client(Error { request: Some(SendTransaction), kind: RpcError(RpcResponseError { code: -32002, message: "**Transaction simulation failed**: Error processing Instruction 0: custom program error: 0x11", data: SendTransactionPreflightFailure(RpcSimulateTransactionResult { err: Some(InstructionError(0, Custom(17))), logs: Some(["Program TokenzQdBNbLqP5VEhdkAS6EPFLC1PHnBqCXEpPxuEb invoke [1]", "Program log: Instruction: TransferChecked", "Program log: Error: **Account is frozen**", "Program TokenzQdBNbLqP5VEhdkAS6EPFLC1PHnBqCXEpPxuEb consumed 1111 of 1111 compute

> units", "Program TokenzQdBNbLqP5VEhdkAS6EPFLC1PHnBqCXEpPxuEb failed: custom program error: 0x11"]), accounts: None, units_consumed: Some(1111), loaded_accounts_data_size: Some(684911), return_data: None, inner_instructions: None, replacement_blockhash: None }) }) })

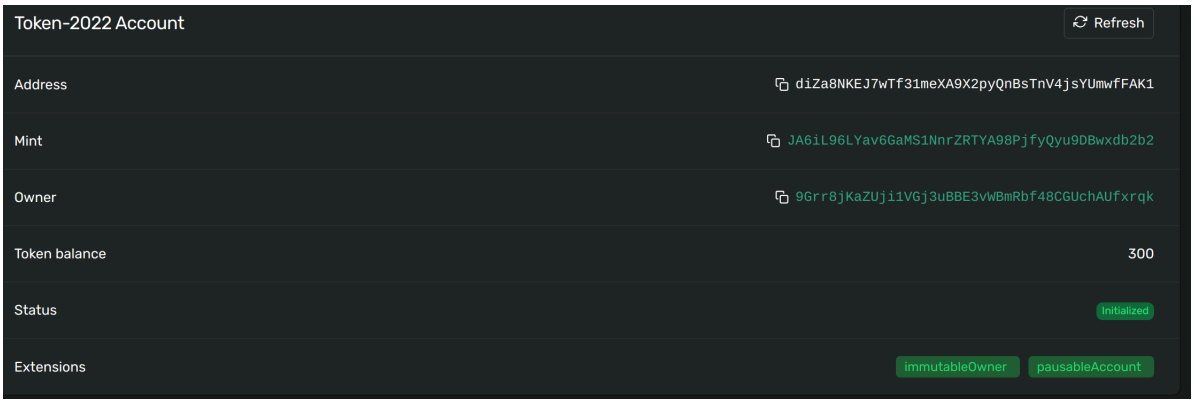
Unfreeze (thaw)

```
spl-token thaw [OPTIONS] <TOKEN_ACCOUNT_ADDRESS>
```

```
solana config set -k $ADMIN_SOLANA_KEYPAIR
spl-token thaw --freeze-authority $ADMIN_SOLANA_KEYPAIR $USER_TOKEN_ACCOUNT
```

Result

> Thawing account: diZa8NKEJ7wTf31meXA9X2pyQnBsTnV4jsYUmwfFAK1
> Token: JA6iL96LYav6GaMS1NnrZRTYA98PjfyQyu9DBwxdb2b2

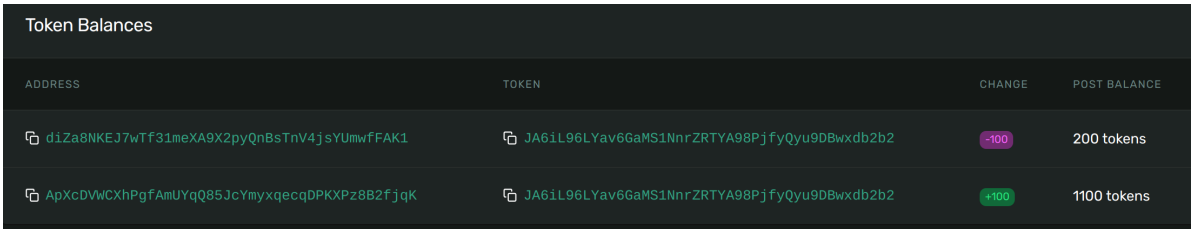


Now we can perform our transfer:

```
solana config set -k $USER_SOLANA_KEYPAIR
spl-token transfer --from $USER_TOKEN_ACCOUNT --owner $USER_SOLANA_KEYPAIR
$TOKEN_MINT 100 $ADMIN_TOKEN_ACCOUNT
```

Result

> Transfer 100 tokens
> Sender: diZa8NKEJ7wTf31meXA9X2pyQnBsTnV4jsYUmwfFAK1
> Recipient: ApXcDVWCXhPgfAmUYqQ85JcYmyxqecqDPKXPz8B2fjqK



Burn Tokens / Forced Transfer (Permanent Delegate)

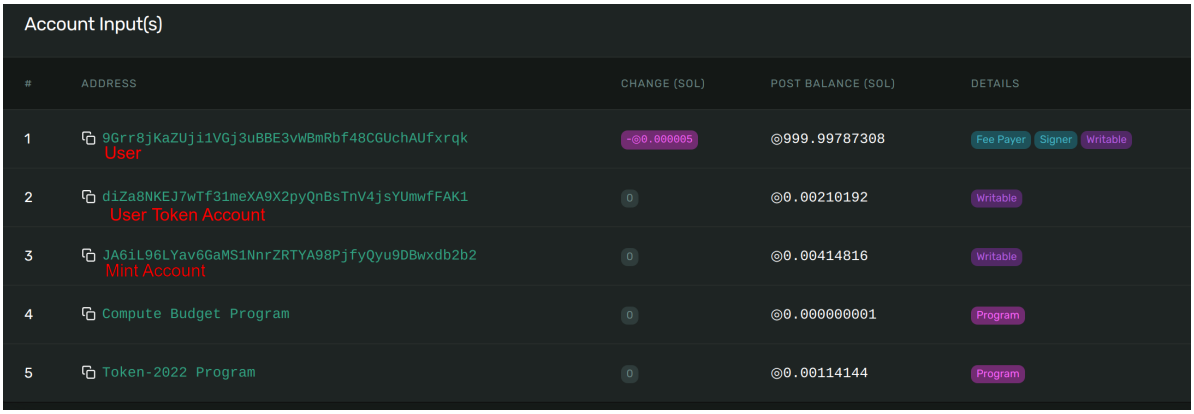
The standard token version already allows a token holder to burn its own token

With Token-2022, it's possible to specify a permanent account delegate for a mint. This authority has unlimited delegate privileges over any account for that mint, meaning that it can burn or transfer any amount of tokens.

```
spl-token burn [OPTIONS] <TOKEN_ACCOUNT_ADDRESS> <TOKEN_AMOUNT>
```

```
spl-token burn $USER_TOKEN_ACCOUNT 5
```

> Burn 5 tokens
> Source: diZa8NKEJ7wTf31meXA9X2pyQnBsTnV4jsYUmwfFAK1



Verification

```
spl-token balance --program-2022 --address $USER_TOKEN_ACCOUNT
```

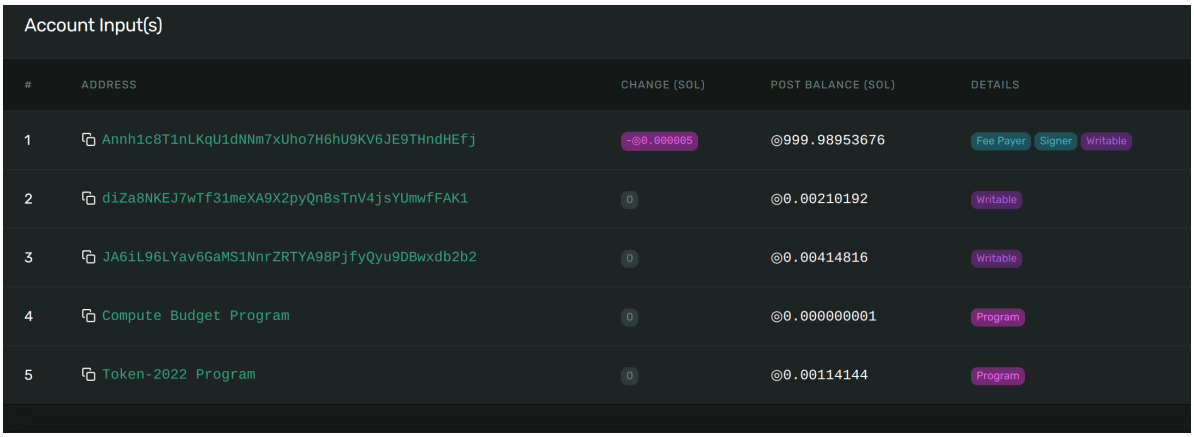
Burn as admin

```
solana config set -k $ADMIN_SOLANA_KEYPAIR
spl-token burn $USER_TOKEN_ACCOUNT 5
```

Result

> Burn 5 tokens
> Source: diZa8NKEJ7wTf31meXA9X2pyQnBsTnV4jsYUmwfFAK1

The signer of the transaction will be the admin



User as signer

If I try to burn admin tokens with my user as the signer, I will have the error `InvalidAccountForFee` because my user does not have the delegate authority.

```
# Change the signer in the config for the user solana config
solana config set -k $USER_SOLANA_KEYPAIR
# try to burn admin token with the user as signer
spl-token burn $ADMIN_TOKEN_ACCOUNT 5
```

Result

> Burn 5 tokens
> Source: ApXcDVWCXhPgfAmUYqQ85JcYmyxqecqDPKXPz8B2fjqK
> Error: Client(Error { request: Some(SendTransaction), kind: RpcError(RpcResponseError { code: -32002, message: "Transaction simulation failed: Error processing Instruction 0: custom program error: 0x4", data: SendTransactionPreflightFailure(RpcSimulateTransactionResult { err: Some(InstructionError(0, Custom(4))), logs: Some(["Program TokenzQdBNbLqP5VEhdkAS6EPFLC1PHnBqCXEpPxuEb invoke [1]", "Program log: Instruction: BurnChecked", "Program log: **Error: owner does not match**", "Program TokenzQdBNbLqP5VEhdkAS6EPFLC1PHnBqCXEpPxuEb consumed 2013 of 2013 compute units", "Program TokenzQdBNbLqP5VEhdkAS6EPFLC1PHnBqCXEpPxuEb failed: custom program error: 0x4"]), accounts: None, units_consumed: Some(2013), loaded_accounts_data_size: Some(684673), return_data: None, inner_instructions: None, replacement_blockhash: None }) }) })

Forced transfer

A forced transfer is performed in the same way as a standard transfer

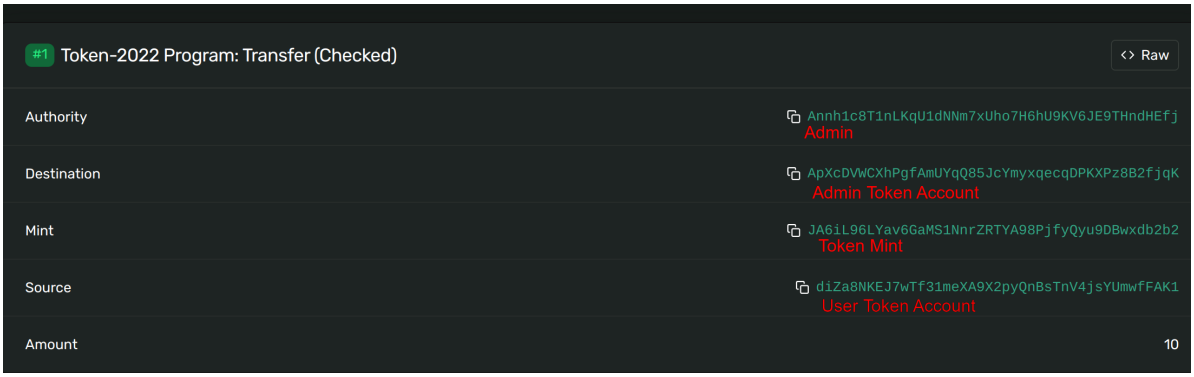
```
spl-token transfer [OPTIONS] <TOKEN_MINT_ADDRESS> \ <TOKEN_AMOUNT> \
<RECIPIENT_WALLET_ADDRESS or RECIPIENT_TOKEN_ACCOUNT_ADDRESS>
```

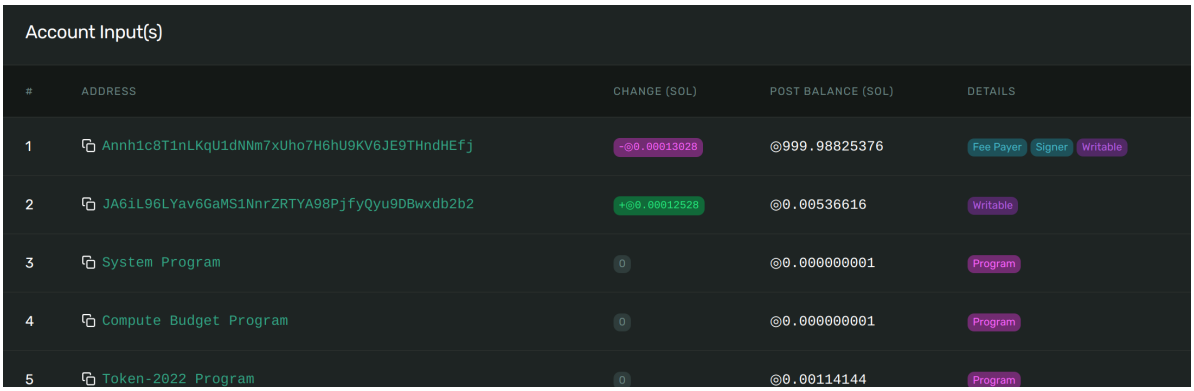
Example

```
# Change the signer in the config for the admin solana config
solana config set -k $ADMIN_SOLANA_KEYPAIR
#  forced transfer tokens from user -> admin with the admin signer key
spl-token transfer --program-2022 --from $USER_TOKEN_ACCOUNT $TOKEN_MINT 10
$ADMIN_TOKEN_ACCOUNT
```

Result

> Transfer 10 tokens
> Sender: diZa8NKEJ7wTf31meXA9X2pyQnBsTnV4jsYUmwfFAK1
> Recipient: ApXcDVWCXhPgfAmUYqQ85JcYmyxqecqDPKXPz8B2fjqK





Pause / Resume All Activity

By enabling the pausable extension on your mint, the program aborts all tranfers, mints, and burns when the `paused` flag is flipped.

This also includes force operation by the admin such as `burn` and `transfer`

Pause

Pause

```
spl-token pause [OPTIONS] <TOKEN_MINT_ADDRESS>
spl-token pause $TOKEN_MINT
```

Result

Pausing mint, burn, and transfer for JA6iL96LYav6GaMS1NnrZRTYA98PjfyQyu9DBwxdb2b2

Trying a transfer will generate *Program log: Transferring, minting, and burning is paused on this mint*

```
solana config set -k $ADMIN_SOLANA_KEYPAIR
spl-token transfer $TOKEN_MINT 10 $USER_TOKEN_ACCOUNT
```

> Transfer 10 tokens
> Sender: ApXcDVWCXhPgfAmUYqQ85JcYmyxqecqDPKXPz8B2fjqK
> Recipient: diZa8NKEJ7wTf31meXA9X2pyQnBsTnV4jsYUmwfFAK1
> Error: Client(Error { request: Some(SendTransaction), kind: RpcError(RpcResponseError { code: -32002, message: "Transaction simulation failed: Error processing Instruction 0: custom program error: 0x43", data: SendTransactionPreflightFailure(RpcSimulateTransactionResult { err: Some(InstructionError(0, Custom(67))), logs: Some(["Program TokenzQdBNbLqP5VEhdkAS6EPFLC1PHnBqCXEpPxuEb invoke [1]", "Program log: Instruction: TransferChecked", "**Program log: Transferring, minting, and burning is paused on this mint**", "Program TokenzQdBNbLqP5VEhdkAS6EPFLC1PHnBqCXEpPxuEb consumed 2192 of 2192 compute units", "Program TokenzQdBNbLqP5VEhdkAS6EPFLC1PHnBqCXEpPxuEb failed: custom program error: 0x43"]), accounts: None, units_consumed: Some(2192), loaded_accounts_data_size: Some(684911), return_data: None, inner_instructions: None, replacement_blockhash: None }) }) })

Resume

Resume mint, burn, and transfer

```
spl-token resume [OPTIONS] <TOKEN_MINT_ADDRESS>
spl-token resume $TOKEN_MINT
```

Resuming mint, burn, and transfer for JA6iL96LYav6GaMS1NnrZRTYA98PjfyQyu9DBwxdb2b2

Update On-Chain Metadata

To facilitate token-metadata usage, Token-2022 allows a mint creator to include their token's metadata directly in the mint account.

```
spl-token update-metadata <TOKEN_MINT_ADDRESS> <FIELD_NAME>
```

Example

```
# Update name, symbol, or URI spl-token update-metadata $TOKEN_MINT name "New CMTAT Token"
spl-token update-metadata $TOKEN_MINT symbol "NEW"
spl-token update-metadata $TOKEN_MINT uri "https://cmta.ch/token_new.json"
# Add custom compliance fields
spl-token update-metadata $TOKEN_MINT TermsUri "https://cmta.ch/token_new.pdf"
spl-token update-metadata $TOKEN_MINT termsHash "0x9c22ff5f21f0b81b113e63f7db6da94fedef11b2119b4088b89664fb9a3cb658"
spl-token update-metadata $TOKEN_MINT jurisdiction "EU-MiCA"
spl-token update-metadata $TOKEN_MINT issuer "CMTA"
```

Result

```
spl-token display $TOKEN_MINT
```

> spl-token display $TOKEN_MINT

> SPL Token Mint
> Address: JA6iL96LYav6GaMS1NnrZRTYA98PjfyQyu9DBwxdb2b2
> Program: TokenzQdBNbLqP5VEhdkAS6EPFLC1PHnBqCXEpPxuEb
> Supply: 1270
> Decimals: 0
> Mint authority: Annh1c8T1nLKqU1dNNm7xUho7H6hU9KV6JE9THndHEfj
> Freeze authority: Annh1c8T1nLKqU1dNNm7xUho7H6hU9KV6JE9THndHEfj
> Extensions
> Close authority: Annh1c8T1nLKqU1dNNm7xUho7H6hU9KV6JE9THndHEfj
> Permanent delegate: Annh1c8T1nLKqU1dNNm7xUho7H6hU9KV6JE9THndHEfj
> Metadata Pointer:
> Authority: Annh1c8T1nLKqU1dNNm7xUho7H6hU9KV6JE9THndHEfj
> Metadata address: JA6iL96LYav6GaMS1NnrZRTYA98PjfyQyu9DBwxdb2b2
> Metadata:
> Update Authority: Annh1c8T1nLKqU1dNNm7xUho7H6hU9KV6JE9THndHEfj
> Mint: JA6iL96LYav6GaMS1NnrZRTYA98PjfyQyu9DBwxdb2b2
> Name: CMTATToken
> Symbol: NEW
> URI: https://cmta.ch/token_new.json
> TermsUri: https://cmta.ch/token_new.pdf
> termsHash: 0x9c22ff5f21f0b81b113e63f7db6da94fedef11b2119b4088b89664fb9a3cb658
> jurisdiction: EU-MiCA
> issuer: CMTA

Remove a custom field

```
spl-token update-metadata $TOKEN_MINT termsHash --remove
```

Result

```
spl-token display $TOKEN_MINT
```

> SPL Token Mint
> Address: JA6iL96LYav6GaMS1NnrZRTYA98PjfyQyu9DBwxdb2b2
> Program: TokenzQdBNbLqP5VEhdkAS6EPFLC1PHnBqCXEpPxuEb
> Supply: 1270
> Decimals: 0
> Mint authority: Annh1c8T1nLKqU1dNNm7xUho7H6hU9KV6JE9THndHEfj
> Freeze authority: Annh1c8T1nLKqU1dNNm7xUho7H6hU9KV6JE9THndHEfj
> Extensions
> Close authority: Annh1c8T1nLKqU1dNNm7xUho7H6hU9KV6JE9THndHEfj
> Permanent delegate: Annh1c8T1nLKqU1dNNm7xUho7H6hU9KV6JE9THndHEfj
> Metadata Pointer:
> Authority: Annh1c8T1nLKqU1dNNm7xUho7H6hU9KV6JE9THndHEfj
> Metadata address: JA6iL96LYav6GaMS1NnrZRTYA98PjfyQyu9DBwxdb2b2
> Metadata:
> Update Authority: Annh1c8T1nLKqU1dNNm7xUho7H6hU9KV6JE9THndHEfj
> Mint: JA6iL96LYav6GaMS1NnrZRTYA98PjfyQyu9DBwxdb2b2
> Name: CMTATToken
> Symbol: NEW
> URI: https://cmta.ch/token_new.json
> TermsUri: https://cmta.ch/token_new.pdf
> jurisdiction: EU-MiCA
> issuer: CMTA

Deactivate token

Burn all tokens

Using the delegate authorities, burn all remaining tokens as seen above.

```
spl-token balance --address $USER_TOKEN_ACCOUNT
```

Result: 150

```
spl-token burn $USER_TOKEN_ACCOUNT 150
```

> Burn 150 tokens

```
spl-token balance --address $ADMIN_TOKEN_ACCOUNT
```

Result: 1120

```
spl-token burn $ADMIN_TOKEN_ACCOUNT 1120
```

```
spl-token supply $TOKEN_MINT
```

Result: 0

Deactivate Authorities

Then you can optionally deactivate all authorities, except the `MintCloseAuthority`

```
spl-token authorize [OPTIONS] <TOKEN_ADDRESS> <AUTHORITY_TYPE> [--]
[AUTHORITY_ADDRESS]
```

Example

```
spl-token authorize $TOKEN_MINT mint --disable
spl-token authorize $TOKEN_MINT freeze --disable
spl-token authorize $TOKEN_MINT pause --disable
```

Result

> Updating JA6iL96LYav6GaMS1NnrZRTYA98PjfyQyu9DBwxdb2b2
> Current mint: Annh1c8T1nLKqU1dNNm7xUho7H6hU9KV6JE9THndHEfj
> New mint: disabled
>
> Updating JA6iL96LYav6GaMS1NnrZRTYA98PjfyQyu9DBwxdb2b2
> Current freeze: Annh1c8T1nLKqU1dNNm7xUho7H6hU9KV6JE9THndHEfj
> New freeze: disabled
>
> Updating JA6iL96LYav6GaMS1NnrZRTYA98PjfyQyu9DBwxdb2b2
> Current pause: Annh1c8T1nLKqU1dNNm7xUho7H6hU9KV6JE9THndHEfj
> New pause: disabled

Close the Mint

The Token program allows owners to close token accounts, but it is impossible to close mint accounts. In Token-2022, it is possible to close mints by initializing the `MintCloseAuthority` extension before initializing the mint.

The Admin must burn all tokens before closing the token mint

```
spl-token close-mint $TOKEN_MINT
```

If you try to mint new tokens:

```
spl-token mint --program-2022 --mint-authority $ADMIN_SOLANA_KEYPAIR
$TOKEN_MINT 300 $USER_TOKEN_ACCOUNT
```

This will generate the following error:

> Error: "Account JA6iL96LYav6GaMS1NnrZRTYA98PjfyQyu9DBwxdb2b2 not found"

CMAT with whitelist

CMTAT Solidity version allows to restrict transactions to a predefined list of approved wallet addresses, known as a **whitelist/allowlist**. This is done through a specific deployment version (`CMTAT Allowlist`) or through the RuleEngine (e.g. `RuleWhitelist`) .

With Solana, this is done by enabling the extension `Default Account State` at the creation of the token.

Command line

With the command-line, this is done by using the following option `--default-account-state` with the argument `initialized` or `frozen`.

```
spl-token create-token \  --program-id
TokenzQdBNbLqP5VEhdkAS6EPFLC1PHnBqCXEpPxuEb \  --decimals  <decimals>\  --mint-
authority < Solana Keypair> \  --enable-permanent-delegate \  --enable-pause \
 --enable-close \  --enable-metadata  --enable-freeze --default-account-state
frozen
```

- With `initialized`, the frozen status by default is not enabled for the moment, but can be enabled later by the authorized authority.
- With `frozen`, all accounts are frozen by default and required to be unfrozen to allow to be a token holder.

Over time, if the mint creator decides to relax this restriction, the freeze authority may sign an `update_default_account_state` instruction to make all accounts unfrozen by default.

```
spl-token update-default-account-state [OPTIONS] <TOKEN_MINT_ADDRESS> <STATE>
```

Example

Label	Value
Admin address	`9G3BN5Jeemo5nQbtPNhcKyeyitHQZ3kti8ARYYD7yEQp`
User address	`DcDkMbpHDSUGXwFroZgE6chGPXFjcL4qr1YReViaMmrL`

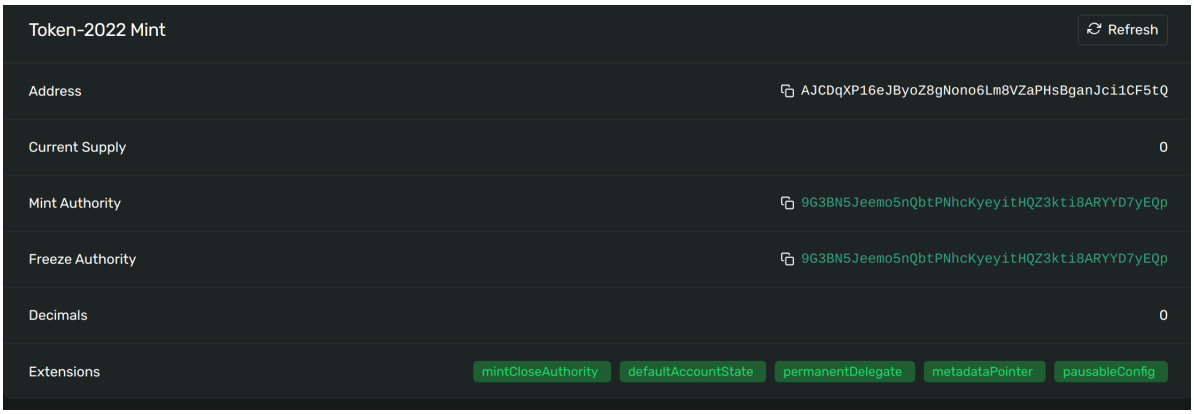
Create token mint

Command

```
spl-token create-token --program-id TokenzQdBNbLqP5VEhdkAS6EPFLC1PHnBqCXEpPxuEb
  --decimals 0 --mint-authority $ADMIN_SOLANA_KEYPAIR --enable-permanent-
delegate   --enable-pause --enable-close --enable-metadata --enable-freeze --
default-account-state frozen
```

Result

> Creating token AJCDqXP16eJByoZ8gNono6Lm8VZaPHsBganJci1CF5tQ under program TokenzQdBNbLqP5VEhdkAS6EPFLC1PHnBqCXEpPxuEb
> To initialize metadata inside the mint, please run `spl-token initialize-metadata AJCDqXP16eJByoZ8gNono6Lm8VZaPHsBganJci1CF5tQ <YOUR_TOKEN_NAME> <YOUR_TOKEN_SYMBOL> <YOUR_TOKEN_URI>`, and sign with the mint authority.
>
> Address: AJCDqXP16eJByoZ8gNono6Lm8VZaPHsBganJci1CF5tQ
> Decimals: 0



In the explorer, we can see that our token mint has the extension `defaultAccountState`

We export our token address in our bash environment

```
export TOKEN_MINT=AJCDqXP16eJByoZ8gNono6Lm8VZaPHsBganJci1CF5tQ
```

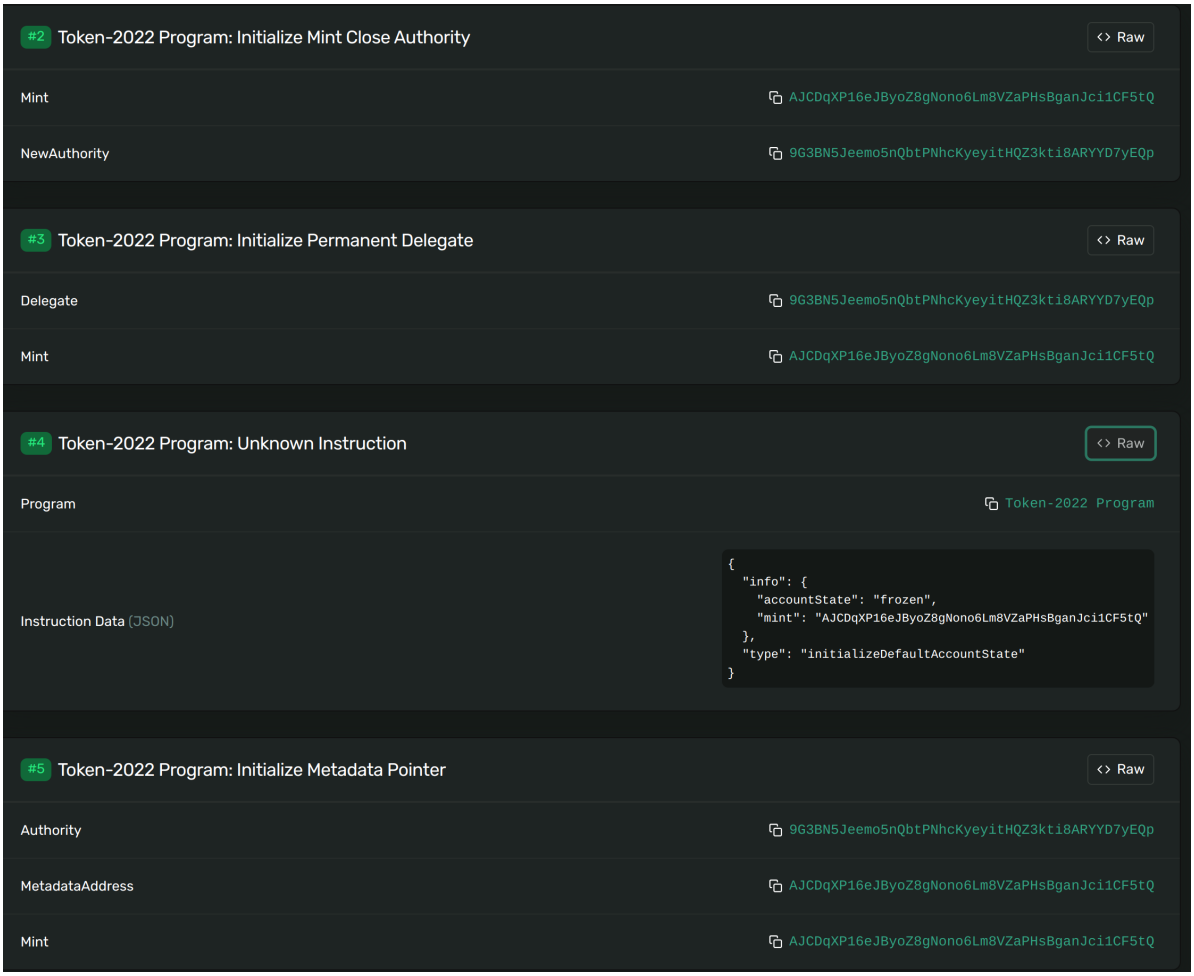
Create token account

We create then the token account for the admin

```
spl-token create-account --program-2022 $TOKEN_MINT --owner
$ADMIN_SOLANA_KEYPAIR
```

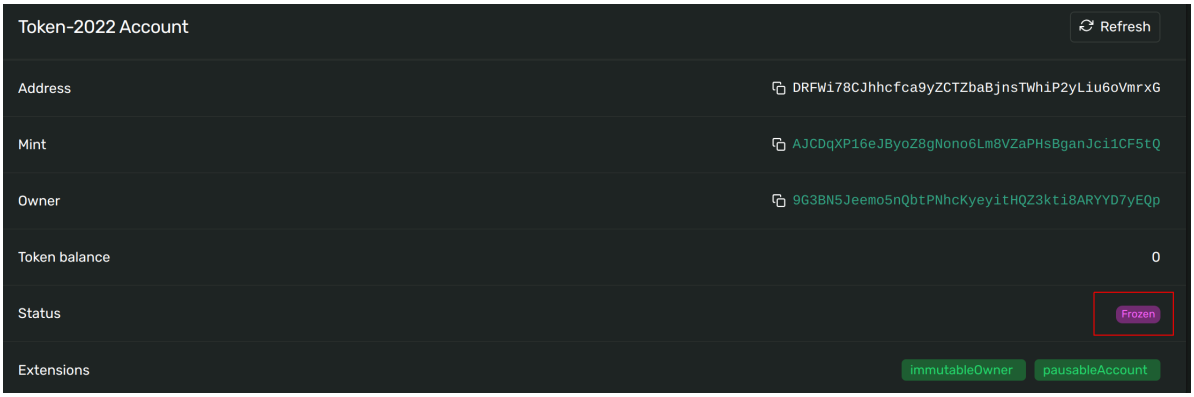
> Creating account DRFWi78CJhhcfca9yZCTZbaBjnsTWhiP2yLiu6oVmrxG

Instruction details



Account status

We can see that the status is `frozen`



We export the token account address

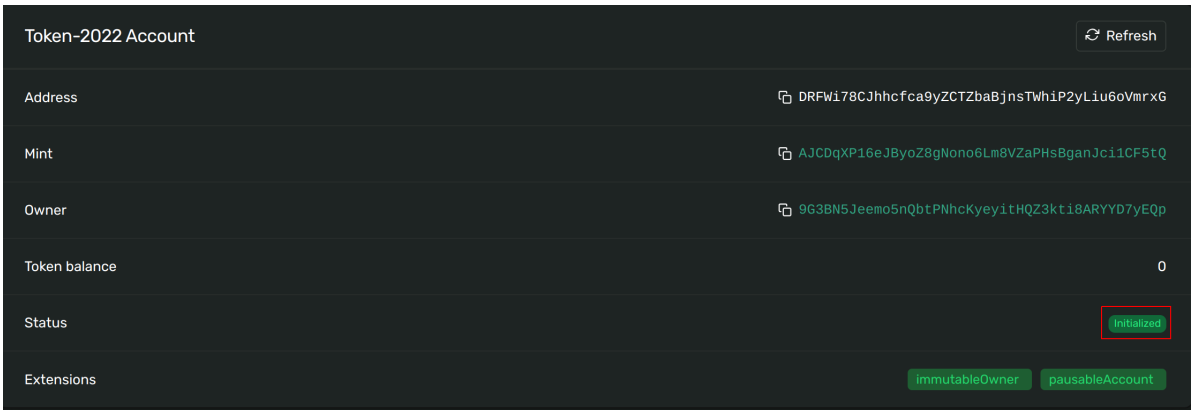
```
export ADMIN_TOKEN_ACCOUNT=DRFWi78CJhhcfca9yZCTZbaBjnsTWhiP2yLiu6oVmrxG
```

Thaw / unfreeze token account

```
solana config set -k $ADMIN_SOLANA_KEYPAIR
spl-token thaw --freeze-authority $ADMIN_SOLANA_KEYPAIR $ADMIN_TOKEN_ACCOUNT
```

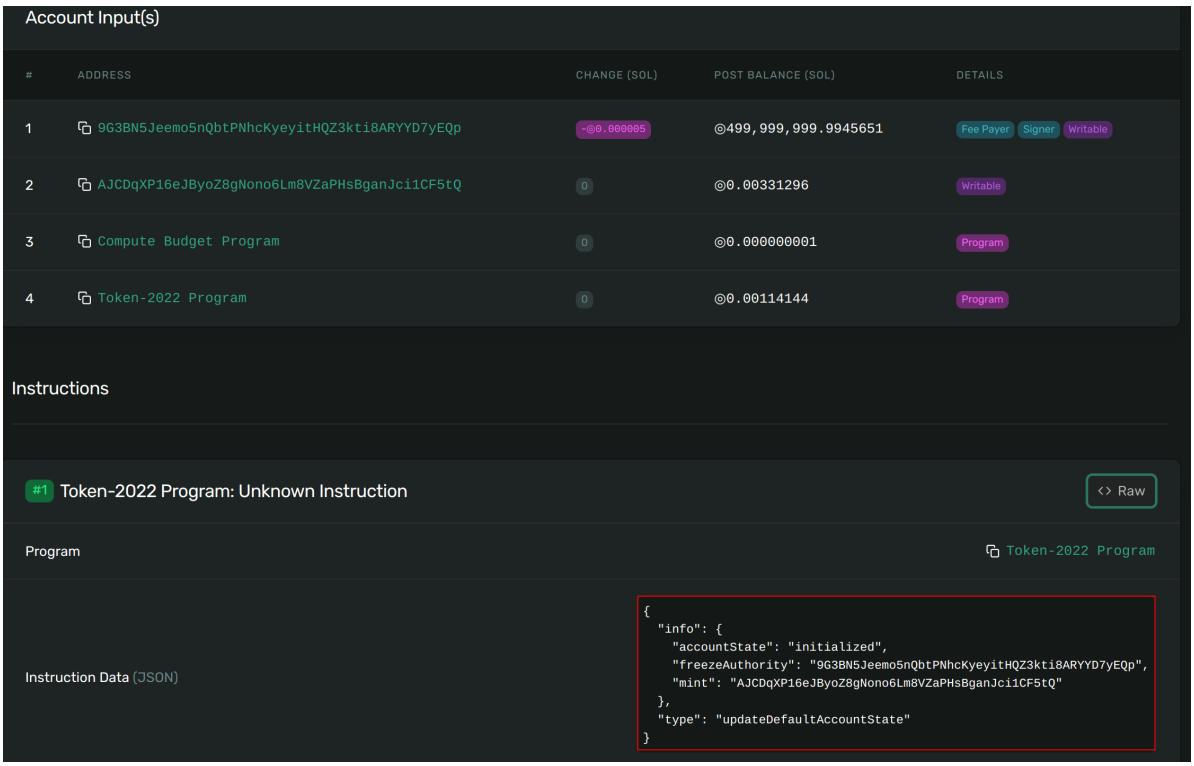
> Thawing account: DRFWi78CJhhcfca9yZCTZbaBjnsTWhiP2yLiu6oVmrxG
> Token: AJCDqXP16eJByoZ8gNono6Lm8VZaPHsBganJci1CF5tQ

New status



Update token mint

```
spl-token update-default-account-state $TOKEN_MINT initialized
```

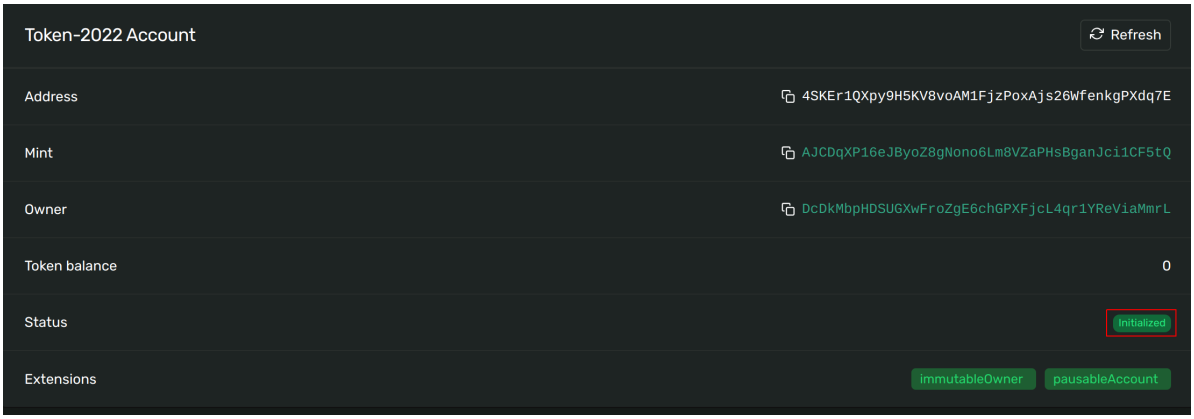


Create token account

```
solana config set -k $ADMIN_SOLANA_KEYPAIR
spl-token create-account --program-2022 $TOKEN_MINT --owner
$USER_SOLANA_KEYPAIR
```

> Creating account 4SKEr1QXpy9H5KV8voAM1FjzPoxAjs26WfenkgPXdq7E

We can see in the explorer that the status of the new created account is `initialized` instead of `frozen`



Reference

- Token
- Solana Program - Token-2022
- Solana - Getting Started with Token Extensions
- Solana Program - Extension Guide
- Solana - Issuing Tokenized Equities on Solana Report