Nonvolatile data

Automation Runtime offers the possibility of storing process variables (see section Nonvolatile variables) and Data objects in nonvolatile memory. Separate nonvolatile memory is required for this (SRAM/FRAM). This memory can only be accessed using low transfer rates, so an image of the nonvolatile data is copied to DRAM (cache) during startup. The nonvolatile PVs in cache are accessed during operation, which enables a high runtime performance. In the event of a reset or power failure, the nonvolatile data is automatically copied from the cache to nonvolatile memory.

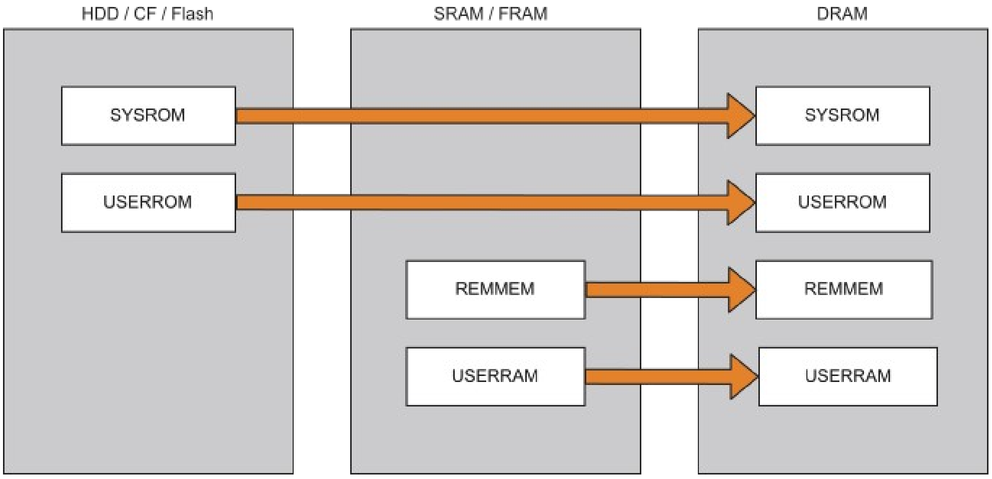
In the case of nonvolatile memory that is equipped with a backup battery, it is important to ensure that the backup battery is sufficiently charged. If the SRAM backup battery is empty, the nonvolatile data will be lost after a certain time in a voltage-free state.

Startup behavior

Memory areas SYSROM and USERROM are located on the hard disk, CompactFlash card or internal flash memory in a voltage-free state. Memory areas REMMEM, REGMEM and USERRAM (see Memory types - SG4) are located in SRAM/FRAM.

During target system startup (booting), Automation Runtime copies the variables and Data objects from the SYSROM and USERROM memory areas to DRAM and the data in REMMEM, USERRAM and REGMEM from SRAM/FRAM to DRAM.

This procedure ensures faster execution at runtime (shorter memory access times).



Industrial PCs with built-in SRAM or an SRAM interface option sometimes operate with direct access to SRAM. USERRAM is therefore not copied to DRAM during startup.

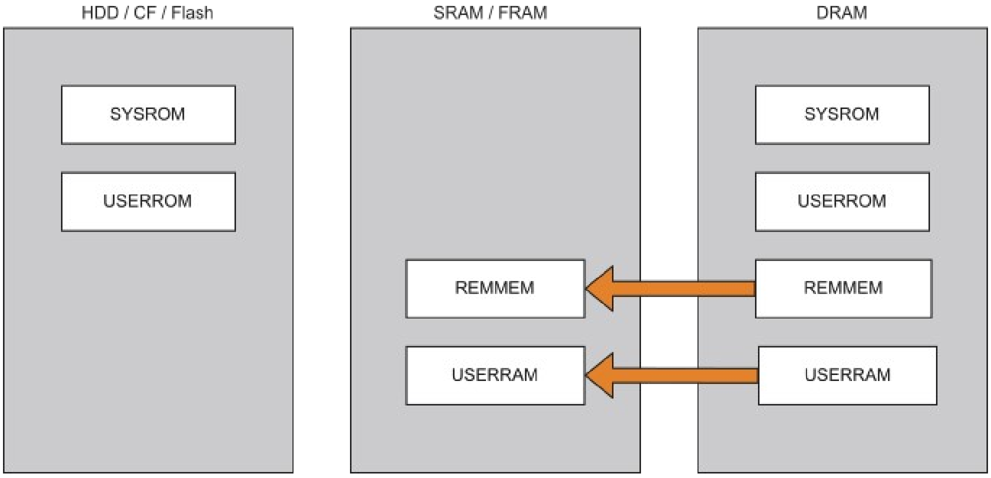
Shutdown

During shutdown, the system is put into a safe state and Automation Runtime backs up the nonvolatile data.

This data backup can be triggered in various ways:

- By software (warm restart, cold restart, etc.)
- By loss of the power supply
- By pressing the reset button

When one of these events occurs, Automation Runtime copies the data from DRAM to the corresponding nonvolatile memory (SRAM/FRAM). File operations are not completed.



Industrial PCs with built-in SRAM or an SRAM interface option sometimes operate with direct access to SRAM. USERRAM is therefore not copied to DRAM during startup. Copying USERRAM at shutdown is also not necessary.

Hardening measures

As described in the previous section, Automation Runtime backs up PVs and data objects to nonvolatile memory during a reset or power failure. Under the following circumstances, however, data may not be copied completely or may be copied incorrectly during a reset or power failure and nonvolatile data will be lost (see Error number 26263):

- Corrupt data structures due to application errors
- Hardware/Software errors (e.g. firmware problems)

There are additional configuration options (hardening measures) for reducing the consequences of a loss of nonvolatile data (in REMMEM and USERRAM) that increase system stability. The following pages describe three hardening methods in more detail:

1. Initialization
2. Asynchronous cyclic backup
3. Synchronous cyclic backup

> These functions are available in Automation Runtime A4.81 and later.

Initialization

If initialization is enabled, this is not a hardening measure. The following describes the difference between an enabled or disabled initialization after an error during shutdown.

Initialization is enabled (default).

By default, the CPU configuration enables the initialization of data in the event of error (*see* CPU properties - Memory configuration).

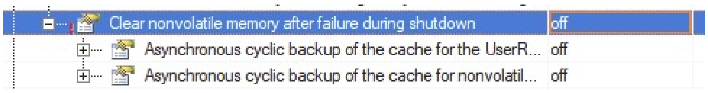
This means that if an error occurs while backing up data to nonvolatile memory, all of the data is initialized with the configured initial values or default initial values per IEC 61131-3. This corresponds to the default behavior of Automation Runtime.

Initialization is disabled (hardening measure).

If the data should not be initialized, initialization of the data in the event of error must be disabled. This means that due to an error during reset or power failure, the data will correspond to the status of the last reset or power failure.

Disabling initialization

1. Open the CPU configuration.
2. Expand the memory configuration (**Memory**).
3. Set parameter *Clear nonvolatile memory after failure during shutdown* to **Off**.



Clear nonvolatile memory after failure during shutdown off
Asynchronous cyclic backup of the cache for the UserR... off
Asynchronous cyclic backup of the cache for nonvolatil... off

See: CPU properties - Memory configuration (Clear nonvolatile memory after failure during shutdown)

Additional CPU power required: None

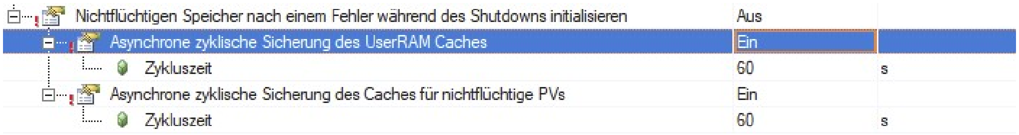
Asynchronous cyclic backup

Asynchronous cyclic backup is another hardening measure. Automation Runtime copies the nonvolatile data (REMMEM/USERRAM) evenly distributed over the entire set cycle time (of the asynchronous cyclic backup) from DRAM to nonvolatile memory. The partial intervals prevent peak loads at specific points.

> In the event of hardware/software errors (e.g. firmware problems), the following situations can occur:
>
> - The values of data objects and PVs may originate from different points in time.
>   Example:
>   Actual values: x=4.1231 (12:00 PM) and y=9.4823 (12:00 PM)
>   Stored values: x=4.1231(12:00 PM) and y=4.2234 (11:55 AM)
>
> If data objects are deleted or added to USERRAM in a backup cycle, no backup is available in this period in which the data objects are deleted or added.

Enabling asynchronous cyclic backup from USERRAM

1. Open the **CPU configuration**.
2. Expand the memory configuration (**Memory**).
3. Set parameter *Clear nonvolatile memory after failure during shutdown* to **Off**.
4. Set *Asynchronous cyclic backup of the cache for the UserRAM* to **On**.
5. Set the*cycle time* of the USERRAM cache. [1 s - 86400 s]



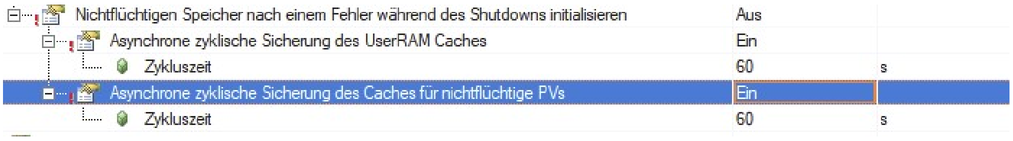
Nichtflüchtigen Speicher nach einem Fehler während des Shutdowns initialisieren	Aus	
Asynchrone zyklische Sicherung des UserRAM Caches	Ein	
Zykluszeit	60	s
Asynchrone zyklische Sicherung des Caches für nichtflüchtige PVs	Ein	
Zykluszeit	60	s

The data objects in USERRAM are now copied cyclically and asynchronously from the cache to nonvolatile memory. The target system ensures that the cycle time is adhered to.

Industrial PCs with built-in SRAM or an SRAM interface option operate with direct access to SRAM. Since USERRAM data remains in SRAM, asynchronous backup is not necessary and not performed by Automation Runtime.

Enabling asynchronous cyclic backup of nonvolatile PVs

1. Open the **CPU configuration**.
2. Expand the memory configuration (**Memory**).
3. Set parameter *Clear nonvolatile memory after failure during shutdown* to **Off**.
4. Set parameter *Asynchronous cyclic backup of the cache for nonvolatile PVs* to **On.**
5. Enter the *cycle time* of the cache for nonvolatile PVs **[1 s - 86400 s]**.



Nichtflüchtigen Speicher nach einem Fehler während des Shutdowns initialisieren	Aus	
Asynchrone zyklische Sicherung des UserRAM Caches	Ein	
Zykluszeit	60	s
Asynchrone zyklische Sicherung des Caches für nichtflüchtige PVs	Ein	
Zykluszeit	60	s

The values of nonvolatile PVs are now copied cyclically and asynchronously from the cache (DRAM) to nonvolatile memory (SRAM). The target system ensures that the cycle time is adhered to.

> Within the application context, the effect must be checked that nonvolatile data can be no older than the set cycle time (of the asynchronous cyclic backup) depending on the selected configuration.

> The asynchronous cyclic backup of USERRAM is only suitable for data objects without checksum monitoring. See DatObjCreate.

Additional CPU power required:

The cyclic copying of the data causes an additional load on the CPU.

The additional load on the CPU is reduced if USERRAM/REMMEM is reduced or the cycle time is increased. The CPU load is independent of the number or size of the data objects in REMMEM/USERRAM.

Asynchronous cyclic backup is only possible up to a certain system tick. This can be calculated as follows:

$$System\ tick\ [\mu s] \leq \frac{cycle\ time\ for\ asynchronous\ \ cyclic\ \ backup\ [s]}{Data\ amount\ [KB]} * 125.000$$

$$System\ tick\ [\mu s] \leq \frac{1s}{256KB} * 125.000 \approx 400\mu s$$

Example:

The following measured values were determined with a system tick of 400 µs.

Target system	Cycle time [s]	Memory size [kB]	Additional CPU load
X20CPx684	60	256	~ 0%
	10	256	~ 2%
	2	256	~ 7%
xPC2200	60	256	~ 0%
	10	256	~ 4%
	2	256	~ 4%
X20CP0484	60	64	~ 0%
	10	64	~ 0%
	2	64	~ 2%

Value of remanent or permanent data after an error during reset or power failure**:** In the event of error, data is only as old as the set cycle time, but it may be inconsistent.

Synchronous cyclic backup

Synchronous cyclic backup is a hardening measure in which only selected PVs are copied from the cache to nonvolatile memory in the task class cycle. Even if an error occurs (see Hardening measures), this data is correct and cannot be distinguished from the normal system behavior. Data modules cannot be backed up with this hardening measure.

Since synchronous cyclic backup requires considerably more CPU resources than asynchronous cyclic backup, this particularly involves important data that must be consistent and current. To reduce the amount of data, individual elements of a structure can be selected instead of the entire structure. It is only ensured that the synchronous backup is active for all selected remanent and permanent PVs after a complete asynchronous backup cycle.

If the cycle time for asynchronous cyclic backup is set to 86400 s (1 day), for example, the synchronous cyclic backup is only active after this day.

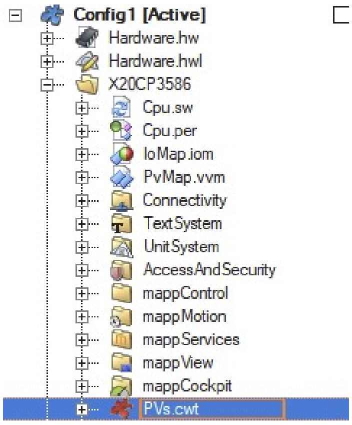
The cyclic backup causes an additional load on the CPU, so it is recommended to only back up very small amounts of data.

> The values of the global PVs are consistent with the respective copying task class. However, task classes with higher priority can interrupt the copying task class and make changes to the PV values.

Enabling synchronous cyclic backup

1. Enable Asynchronous cyclic backup for nonvolatile PVs.
2. Add a CWT file.

   Change to the Configuration View and select the target system. Then select a *.cwt file* in the Object Catalog and add it by double-clicking. Any name can then be assigned.



3. Open the CWT file by double-clicking and add PVs (see CWT editor).

CPU power required in addition to asynchronous cyclic backup:

Target system	Task class cycle time [ms]	Memory size [byte]	Additional CPU load
X20CPx684	10	256	~ 2%
	1	128	~ 7%
xPC2200	10	256	~ 1%
	1	128	~ 4%
X20CP0484	10	256	~ 2%
	1	128	~ 7%

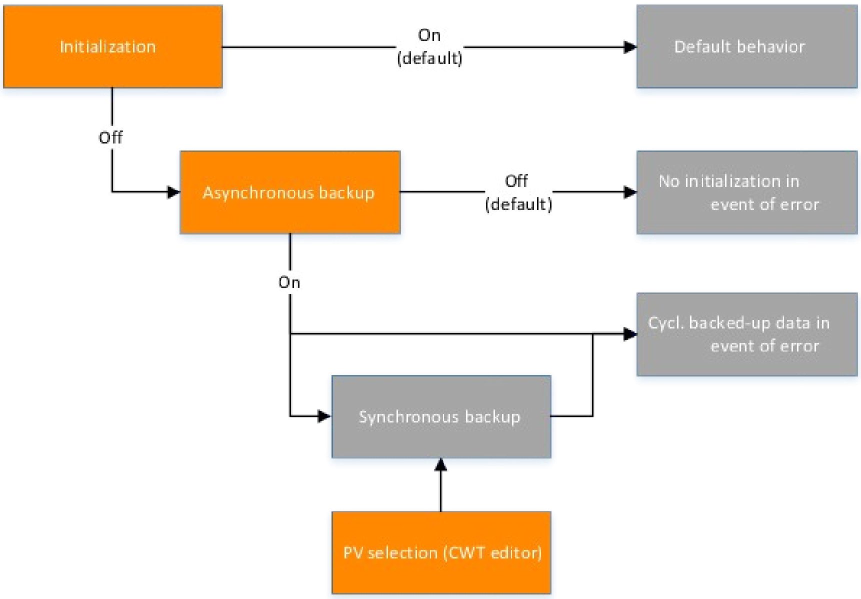
> The performance of the synchronous cyclic backup can degrade when using this backup type in several task classes rather than a single one. (The execution time of a task class is extended; the task classes can then be increasingly interrupted by higher priority tasks. A single large copy performs better than several small ones.)

Profiler

Profiler events are generated to determine the additional load per task class caused by the synchronous cyclic backup. The synchronous cyclic backup takes place after the cyclic programs are executed. The start and end of the backup are shown in the Profiler graphic (see section Profiler).

Dependencies

- Initialization: Initialization is enabled by default. In the event of error, Automation Runtime initializes all PVs during the next startup with the configured initial values or default initial value per IEC 61131-3; data objects are deleted.
- Asynchronous cyclic backup: In order to enable asynchronous cyclic backup, initialization in the event of error must be disabled (off) . In the event of error, Automation Runtime copies the data from volatile memory to nonvolatile memory evenly distributed over the entire set cycle time.
- Synchronous cyclic backup: Automation Runtime copies the PVs selected in the CWT editor in the task class cycle from volatile memory to nonvolatile memory. The synchronous cyclic backup is performed in addition to the asynchronous cyclic backup.



Use cases

Settings

Example:

During commissioning of a packaging machine, necessary parameters (e.g. positions) are individually adjusted and remanently stored.

Hardening measures

- Disable Initialization.
  (In the event of error, remanent data is in the state from the last shutdown.)
- If necessary, Asynchronous cyclic backup
  (In the event of error, remanent data is only as old as the set cycle time.)

Product shift register

Example:

In a packaging machine, shift registers are used to track the product flow. A variety of remanent properties are typically stored for each product, such as OK, scrap, in which station the scrap was noted and why. Using this information, the product can be processed correctly, e.g. in further stations, or it can be sorted out. For tracking purposes, key process figures such as the closing torque of a screw cap can also be stored in the shift register.

Hardening measures

- Synchronous cyclic backup

Axes with absolute encoders

Example:

Servo drives with absolute encoders are used in a processing machine. Remanent/Permanent memory is required to store the reference value for the necessary "endless position".

Hardening measures

- Synchronous cyclic backup