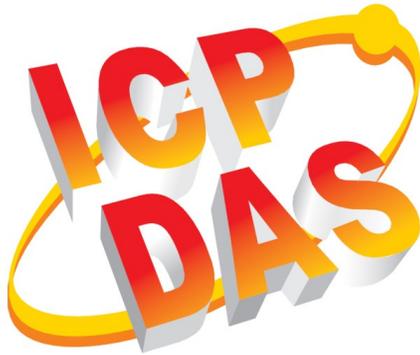


# **Win-GRAF PC-Runtime**

**for Windows® Operation System**

## **User Manual**

**(Version 1.1)**



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## Revision

Revision	Date	Description	Author
1.0	27.06.2022	Initial version	M. K.
1.1	28.03.2024	Describe the function of Win-GRAF Runtime Utility Version 1.0.0.3	M. K.

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## 1 Introduction

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This manual is an extension to the '*Win-GRAF Workbench User Manual*' and describes the configuration procedure necessary to develop applications for the Windows Win-GRAF runtime. This runtime version is developed for the standard Windows OS and does not support real time and deterministic behavior. It supports multitasking programming with priority settings.

The PLC application for the runtime has to be developed using the Win-GRAF Workbench, which is not included in the runtime package and has to be ordered separately. The workbench supports all five IEC-61131-3 programming languages as well as multitasking programming with priority settings.

In addition real-time EtherCAT and PLCopen defined motion control is supported when using the runtime together with the EtherCAT master card series ECAT-M801 of ICPDAS. The ECAT-M801 device is a PCIe card with an integrated real-time EtherCAT master and a multi-axis motion kernel. The motion engine and the EtherCAT master are running on a dedicated processor in a real-time environment to achieve a time-deterministic control of the EtherCAT application. Single axis and coordinated multi-axis PLCopen commands are part of the Win-GRAF library. The integrated EtherCAT master supports all standard EtherCAT slaves from simple IO modules, encoder, stepper controller to servo drives. The user manual "PLCopen\_User\_Manual" provides further information on the EtherCAT network configuration and the behavior of the PLCopen commands.

All standard Modbus protocols (TCP, RTU, ASCII) are supported. The Modbus functions are introduced in the "Modbus" manual.

The "OPC UA Server\_User\_Manual" contains step-by-step configuration examples for the integrated OPC UA server.

HMI software provided by ICPDAS such as eLogger and Indusoft can be installed directly on the PC Windows OS. The 'HMI\_User\_Manual' describes the data exchange mechanism and the required communication configuration to establish data exchange between Win-GRAF runtime and HMI. In addition the manual describes how to allow external programs (e.g. LabVIEW, C#, C++ ) to exchange data with the PLC application.

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## 2 Runtime Installation

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### 2.1 Installing Win-GRAF PC-Runtime

The **Win-GRAF PC-Runtime** version is developed for the standard Windows operation system. It is a 32 bit application and supports any Window OS version 7 (32 or 64 bit) or later.

System requirements:

- Operation system: Windows 7, Windows 8, Windows 10, 11 (32-bits or 64-bits)
- RAM: 1 GB minimum (Recommended: 2 GB or more)
- Available hard-disk space: 200 MB minimum

Installation Steps:

1. Download the runtime installation file from the ICPDAS website
2. Double-click the "Win-GRAF\_PC-Runtime\_Vxx.xx\_Setup.exe" setup execution file and follow the installation steps.

### 2.2 Run Win-GRAF Runtime

Start the runtime by clicking "Start Win-GRAF PC-Runtime" in the start menu. Only one runtime process is allowed to execute on the same PC at a time. The runtime execution file and DLLs can be copied to another directory and executed there if necessary. The USB runtime key has to be plugged into the PC in order to execute the full runtime version. Without USB key the runtime stops executing after about 15 minutes.

**Important:**

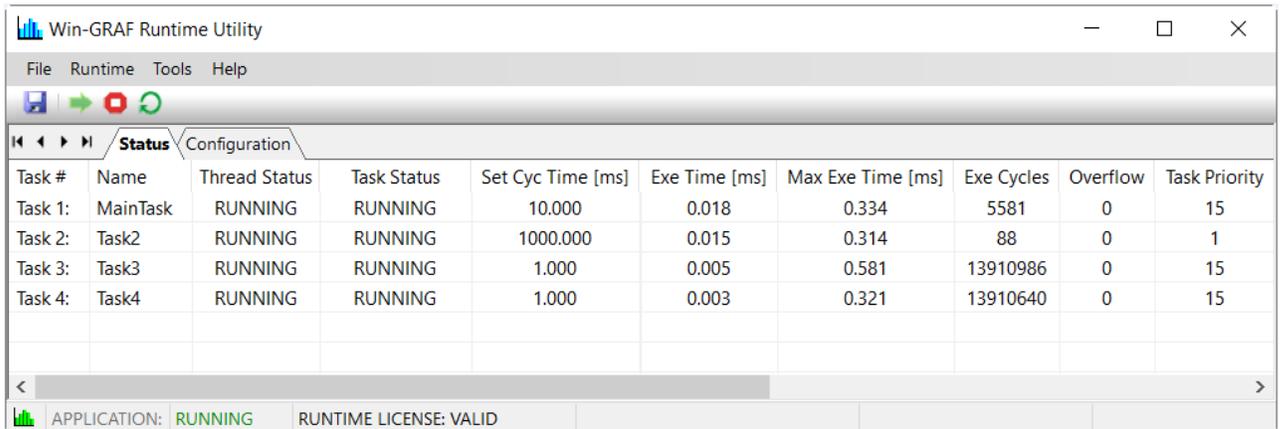
The **Win-GRAF PC-Runtime** version 12.0 is only compatible with Win-GRAF Workbench Version 12.0 or higher.

## 3 Runtime Configuration

The **Win-GRAF PC-Runtime** version supports multitasking programming. Up to 32 tasks are supported but to achieve optimal performance not more than four tasks should be used for an application. By default the runtime is set to support four tasks. The number of supported tasks can be increased or decrease using the '*Win-GRAF Runtime Utility*'.

### 3.1 Win-GRAF Runtime Utility

The main purpose of the utility is to configure, start and stop the PLC application. In addition, it monitors the status of each task, such as: E.g. the task execution time, priority settings, number of execution cycles, etc. (Figure 1). In the event of an error, the error type is displayed in the 'Status' tab. The utility allows direct deletion of compiled PLC application execution files.



The screenshot shows the Win-GRAF Runtime Utility application window. The window title is "Win-GRAF Runtime Utility" and it has a menu bar with "File", "Runtime", "Tools", and "Help". Below the menu bar are several icons: a folder, a green play button, a red stop button, and a green refresh button. The main area is divided into two tabs: "Status" (selected) and "Configuration". The "Status" tab displays a table with the following data:

Task #	Name	Thread Status	Task Status	Set Cyc Time [ms]	Exe Time [ms]	Max Exe Time [ms]	Exe Cycles	Overflow	Task Priority
Task 1:	MainTask	RUNNING	RUNNING	10.000	0.018	0.334	5581	0	15
Task 2:	Task2	RUNNING	RUNNING	1000.000	0.015	0.314	88	0	1
Task 3:	Task3	RUNNING	RUNNING	1.000	0.005	0.581	13910986	0	15
Task 4:	Task4	RUNNING	RUNNING	1.000	0.003	0.321	13910640	0	15

At the bottom of the window, there is a status bar with a green bar and the text: "APPLICATION: RUNNING" and "RUNTIME LICENSE: VALID".

Figure 1: Win-GRAF PC-Runtime Utility

The utility is also responsible for checking the license status. It will clearly indicate whether the runtime license is invalid or the PLC application has been compiled by an workbench trial version:

- PLC application compiled with the workbench trial version will only run for about 20 minutes
- A runtime without a valid license will automatically terminate its execution after 20 minutes.

### 3.1.1 Communication Port Setting

In order to establish a TCP/IP communication the workbench needs to know the IP address and the socket port number of the target runtime. Two PLC applications project types are supported by the PC platform:

- Single-task project
- Multi-tasking project

For single-task projects, the default communication port for downloading and debugging the application is set to 1100. The default port number can be changed via the '*Win-GRAF PC-Runtime Utility*'.

In multi-tasking projects, each PLC task communicate via its own port number with the Workbench. By default, the port number of the '*Main task*' is set to 1100. The port number of each subsequent task is incremented by one in task number order: port 1101 for Task2, port 1102 for Task3, etc.

If necessary, the port number of the '*Main task*' and thus the other tasks can be changed via the '*Win-GRAF PC-Runtime Utility*' by setting the '*Main Task Port*' value(Figure 2). Confirm and save the setting with '*Set*' and '*File\Save*'.

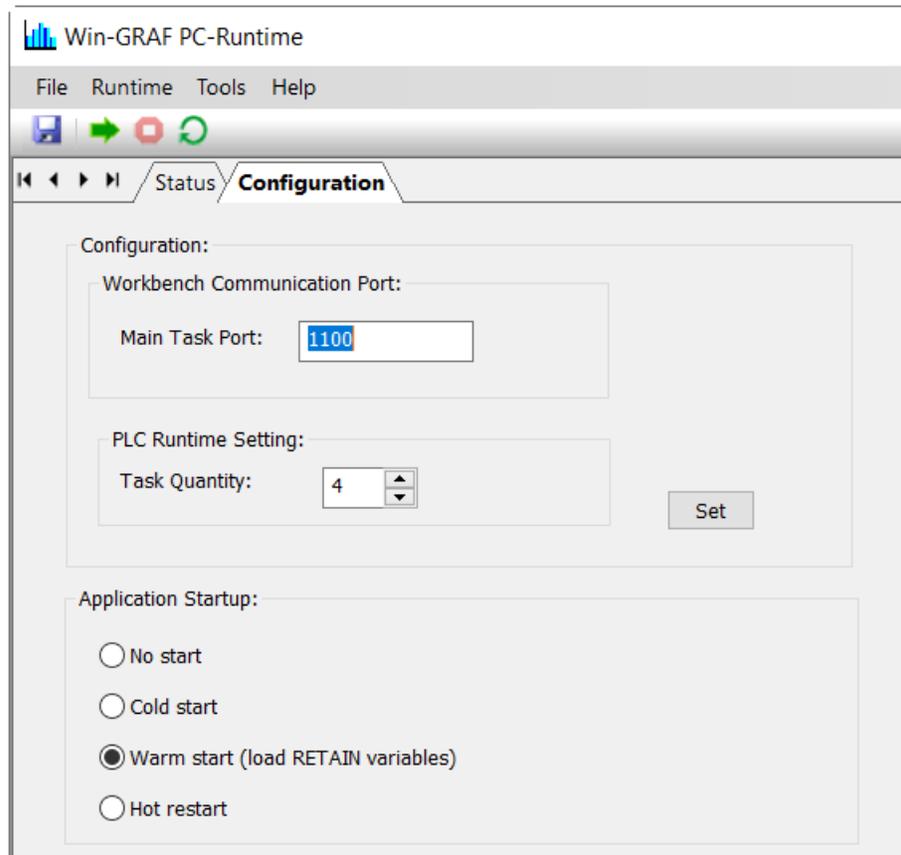


Figure 2: Utility configuration interface

Make sure the workbench Ethernet TCP/IP port setting (Figure 3) is set to the 'Main Task Port', otherwise the connection to the PC runtime cannot be established.

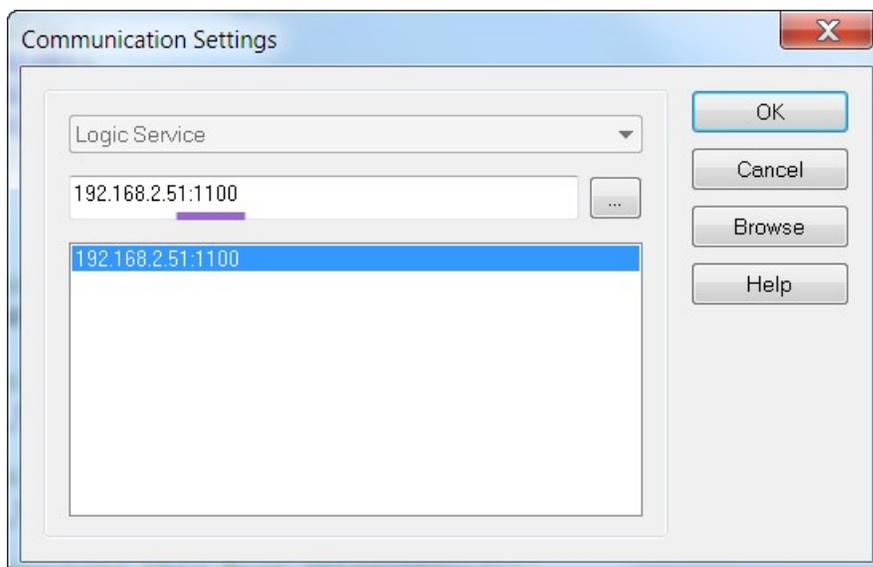


Figure 3: Workbench communication setting

### 3.1.2 Task Number Setting

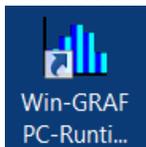
The PC runtime supports a maximum of 32 tasks. By default, the task number is limited to four tasks, which means that a PLC application can use fewer than four tasks, but cannot exceed this number. The user can change the supported task count to a higher or lower limit by directly editing a value in the '*Task Quantity*' box (Figure 2) of the Win-GRAF Runtime Utility. Confirm and save the setting with '*Set*' and '*File\Save*'.

## 3.2 Configuration Procedure

In order for the compiled PLC application to be downloaded and executed from the workbench, both the communication settings and the configuration of the number of tasks in the workbench and the runtime must be identical. Next, the basic configuration process is shown:

**Step 1:** Start the Win-GRAF PC-Runtime utility:

1. Double click the Win-GRAF runtime icon on the desktop to start the Win-GRAF Runtime utility.



**Step 2:** Stop the PLC application execution if it is running: Click the stop command 

**Step 3:** Set the communication parameters between workbench and runtime:

1. **Runtime configuration:** Set the TCP/IP port number used by the workbench to download and debug the PLC application. The runtime server listen on all Ethernet ports of the PC. It is suggested to use the default port number of 1100 for the main task. Only change this port number if it conflicts with the port number of another program running on the same PC.

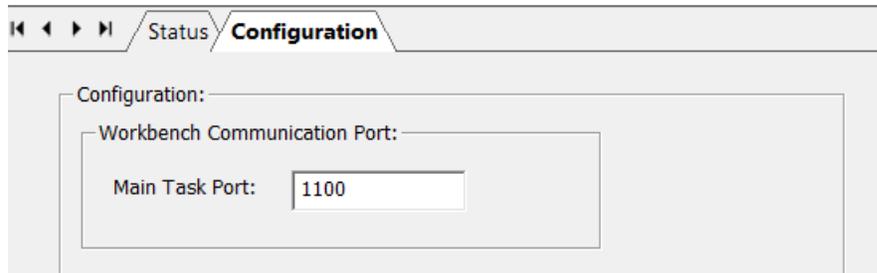


Figure 4: Runtime TCP/IP port number on PC (Runtime Utility)

2. **Workbench configuration:** Set the IP address and socket port number of the target runtime.
  - Select '*Tools/Communication Settings...*' from the menu
  - Edit IP address and port number of the target runtime. Both parameters have to be separated by a colon. Only Ethernet TCP/IP communication is being supported.
  - Click "OK"

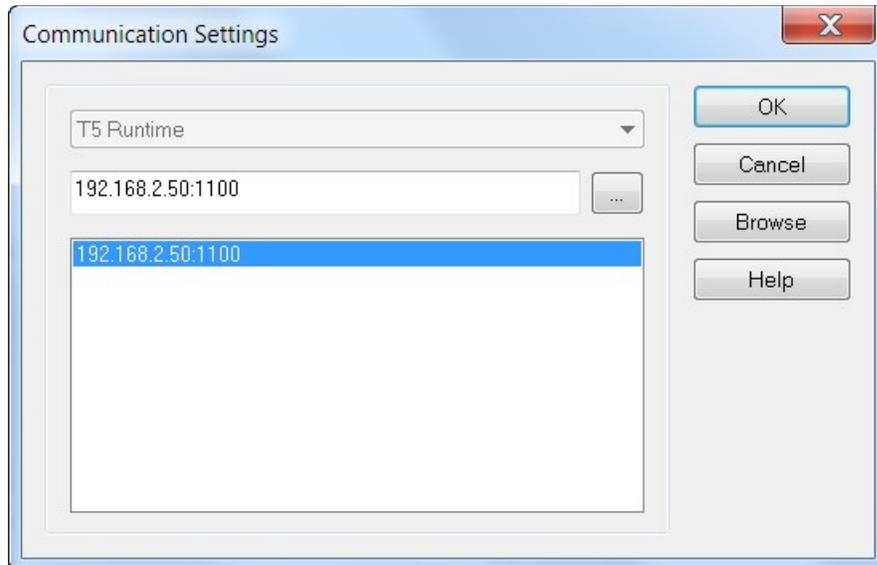


Figure 5: Workbench communications setting

The current communication setting is being displayed at the bottom of the screen. The setting can be directly modified by double clicking the IP address in the status bar.

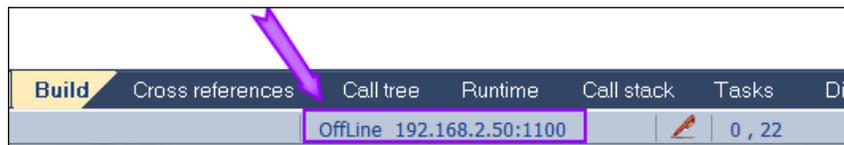


Figure 6: Workbench status bar

**Step 4:** Set the maximum number of tasks supported by the runtime.

1. **Runtime configuration:** The default runtime setting supports up to four tasks and meets the requirement for most applications. If necessary enter a new task value for the task quantity. Click 'Set' and save the setting.

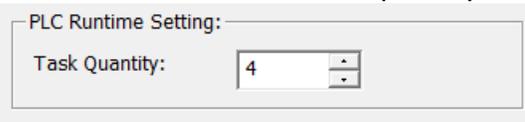


Figure 7: Supported runtime task quantity setting (Runtime Utility)

2. **Workbench setting:**

- (i) Single-Tasking project

- i. On the 'Start Page' click 'Create Singletask Project' to open the single-task project wizard.
    - ii. Select 'Project (WG)'
    - iii. Enter project destination folder and name.
    - iv. Click 'Next'
    - v. Select '**Windows PC-Runtime**' controller or click on the 'Auto-Detect' button to determine the controller type.
    - vi. Select programming language
    - vii. Confirm the setting with 'Finish'. A new single project is created.

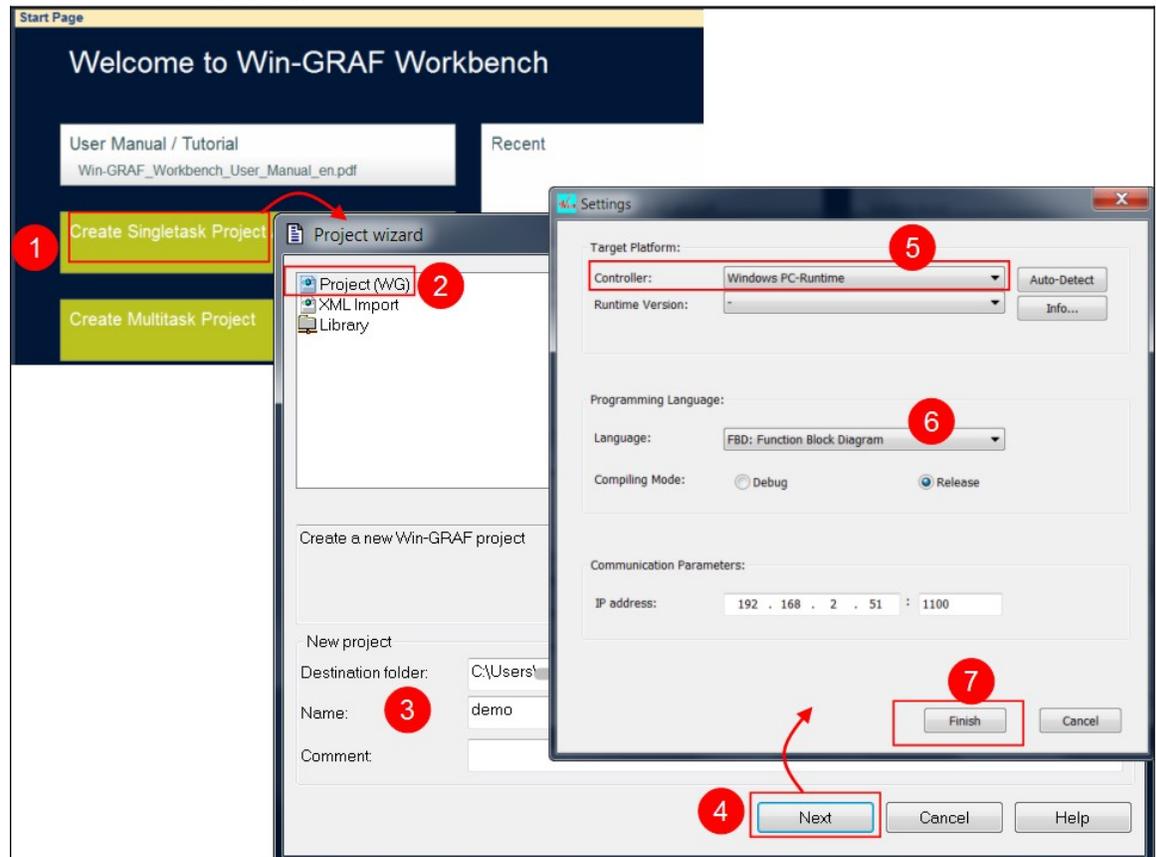


Figure 8: Create a new single-task Workbench project

- (ii) Multi-Task project:
  - i. On the 'Start Page' click 'Create Multitask Project' to open the multi-task project wizard.
  - ii. Enter project destination folder.
  - iii. Enter project name.
  - iv. Select the number of task to use. Make sure the task count is not greater than the runtime setting
  - v. Select target platform: '**Windows PC-Runtime**'
  - vi. Click 'OK' to confirm the setting.

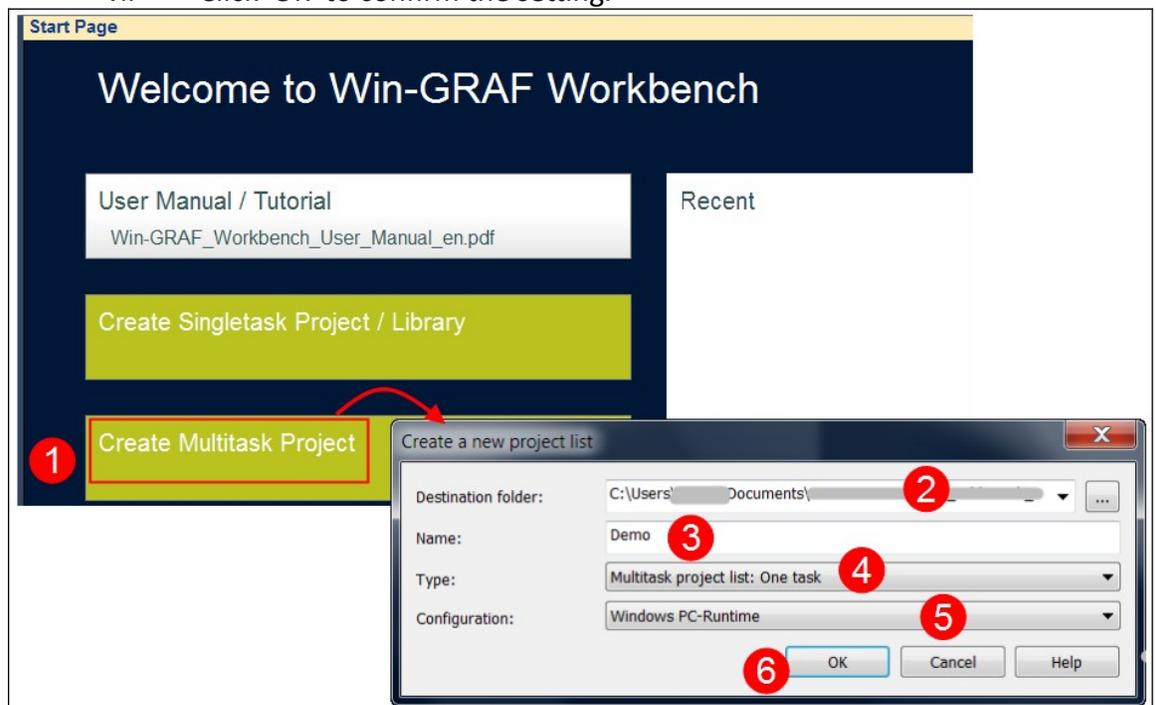


Figure 9: Create a new multi-task Workbench project

- Step 5:** Determine how the PLC logic application should launch. Several options are available:
- 1. **No Start:** The logic control application does not start with the '*Win-GRAF PC-Runtime Utility*'
  - 2. **Cold Start:** The application starts with the utility. All application variables are initialized at startup according to the "Init Value" setting.

Name	Type	Di...	Attrib.	Syb.	Init value
<ul style="list-style-type: none"> <li>Main               <ul style="list-style-type: none"> <li>dwVar UDINT <input type="checkbox"/></li> <li>Global variables</li> <li>RETAIN variables                   <ul style="list-style-type: none"> <li>reVar UDINT <input type="checkbox"/></li> </ul> </li> </ul> </li> </ul>					UDINT#0
					UDINT#0

3. **Warm Start:** All application variables except the "RETAIN variables" are initialized at startup according to the "Init Value" setting. The "RETAIN variables" use the last values before the application stopped.
4. **Hot restart:** No variables are initialized at startup. All variables use the last values before the application stopped. These mode is mainly used for debugging process and it is not supported by all function blocks (e.g. PLCopen FB).



Figure 10: Launch the PLC application along with the utility option (Runtime Utility)

- Step 6:** Save the setting: Click 'Set' button and select 'File\Save' from the menu. The next time you start the utility, the logic application will start accordingly.

## 4 Download Application

After the PLC application is successfully compiled, the application has to be downloaded to the runtime for execution. In Win-GRAF, the data exchange between the workbench and the runtime takes place via TCP/IP communication.

1. The PLC application is written and compiled in the Win-GRAF workbench
2. Download compiled application
3. The Win-GRAF runtime executes the application

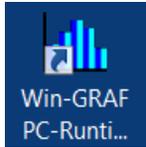
Task #	Name	Thread Status	Task Status	Cycle Time [ms]	Real Cycle Time [ms]	Max Cycle Time [ms]	Exe Cycles
Task 1:	MainTask	RUNNING	RUNNING	0	0.001000	0.114000	1880613
Task 2:	-	-	-	-	-	-	-
Task 3:	-	-	-	-	-	-	-
Task 4:	-	-	-	-	-	-	-

Figure 11: Edit and download PLC program

Procedure for downloading the compiled application:

**Step 1:** Start the Win-GRAF runtime utility if it is not running:

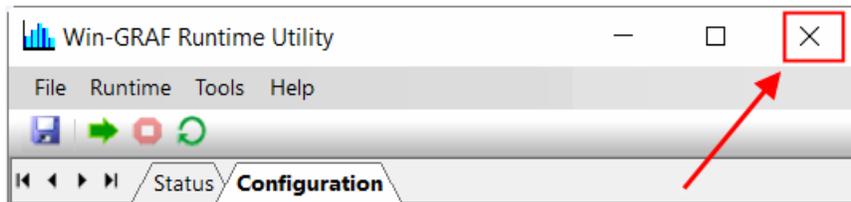
1. Double click the Win-GRAF runtime icon on the desktop to start the Win-GRAF Runtime utility.



The status bar of the utility indicates whether the runtime has been successfully started. In addition the runtime license status will be shown. If the license is invalid the runtime automatically stops running after 20 minutes.



**Attention:**



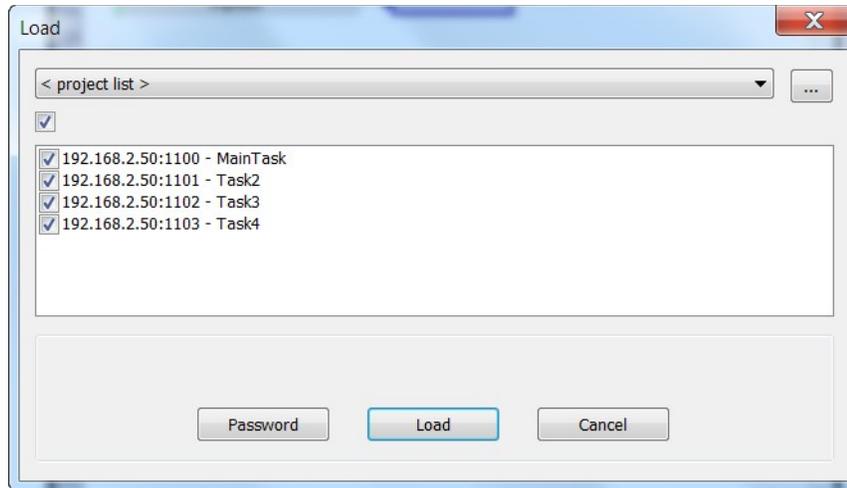
Clicking the window close button does not exit the utility, but only closes the user interface (UI) and adds the corresponding icon to the toolbar in the right section of the taskbar. Even though the utility's interface is not visible, all of its functions and associated runtime are still active and running normally. To display the interface again, simply click the corresponding icon in the toolbar.



To exit the utility including the PLC application, click the '*File\Exit Runtime and Utility*' menu.

**Step 2:** Download the built plc application to the runtime:

- Click the download button in the toolbar or select '*Project\Download All Projects...*'. . The figure below shows an example of an application program with four tasks.
- Click '*Load*' to start the download process



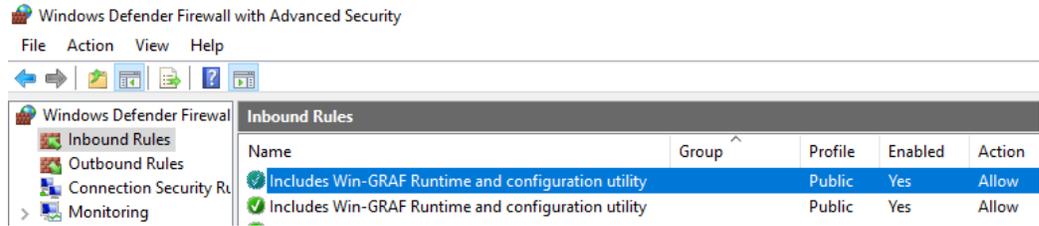
Wait until the download has finished.

**ATTENTION:**

The runtime stops executing the currently running logic application when a new application file is downloaded. Enabling "Online change" mode ensures that the application runs continuously even when downloading minor application changes.

**Note:**

- By default all tasks files are selected for download. For large PLC programs: To shorten the download time, disable the task files that have not been changed since the last download.
- After the download process is complete, the application will not restart automatically. This has to be done by the user. The user can decide between a cold or warm restart. With a cold start, the PLC program starts again with the initial values; with a warm start, the program uses retentive data. Not all function blocks support warm start (e.g. PLCopen function blocks)
- Possible causes if the workbench fails to download the application program:
  - Incorrect workbench IP address setting. The IP address entered in the workbench does not match with the address of the PC target platform.
  - Incorrect network and subnet setting.
  - Firewall of the PC blocks the port used by the workbench. Make sure the port has been enabled for public use.



**Step 3:** Create an online connection between workbench and the runtime

- Click the 'On Line' button on the toolbar or



- Enter "Ctrl+F5".

**Step 4:** Start the PLC application:

Normally the 'Start mode' window automatically pops up right after an online connection. Select your required start mode to start the logic control application.

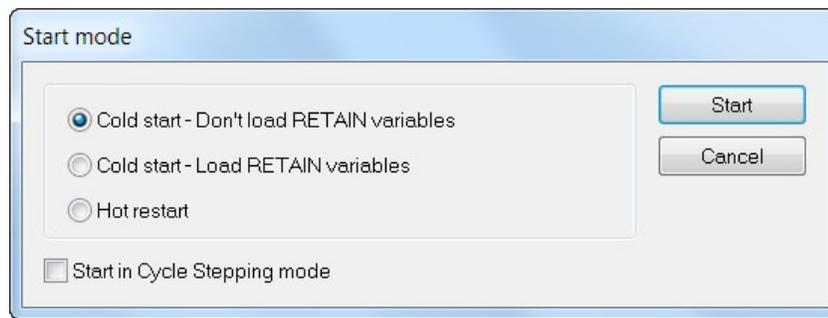
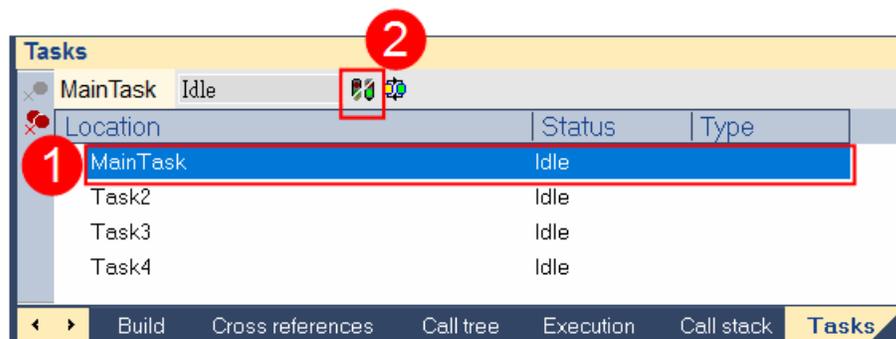


Figure 12: Start mode dialog

For multi-tasking project:

If the 'Start mode' window does not pop up during the previous step, then you can open this window as follows:

- Go to the 'Tasks' tab output window at the bottom. All tasks are shown in idle mode.



- First select the 'MainTask' and click the traffic light button. Now the 'Start

*mode*' window pops up, which allows you to select the start mode of the PLC application.

The main task starts executing the other tasks when the SYSSTARTTASK() function is called from the main task. Each task can be started manually by selecting it in the 'Tasks' tab output window and activating the traffic light button.

After clicking 'Start' of the 'Start mode' window (Figure 12) the 'Main Task' and the tasks being called by SYSSTARTTASK() will enter the run status.

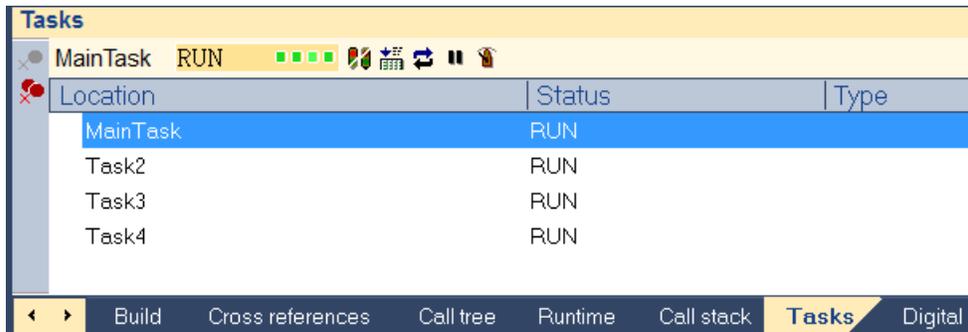


Figure 13: Tasks status tab

The Win-GRAF runtime utility (Figure 14) shows the status of the runtime and its tasks. Further information of each task are shown e.g. the cycle time, number of execution cycle, errors, priority setting, etc..

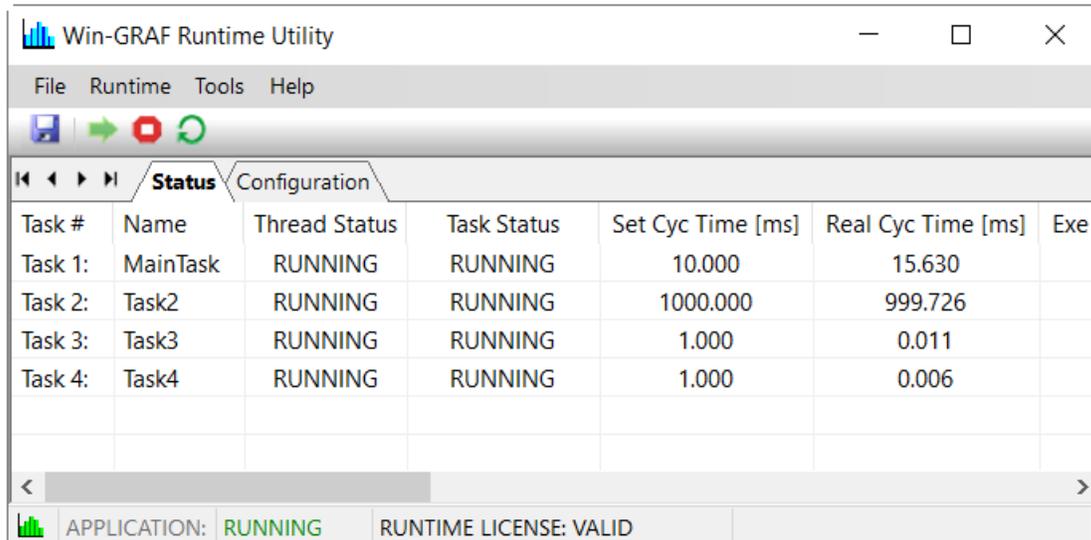


Figure 14: Win-GRAF Runtime Utility

# 5 Multitasking

## 5.1 Task Setting

The cycle of each task has to be set directly from the workbench by right-clicking on the task name and selecting 'Task...' from the pop-up menu. Double click the period column next to the task to enter the cycle time. If only one task is being used then the 'Run as fast as possible' option can be used (Figure 15).

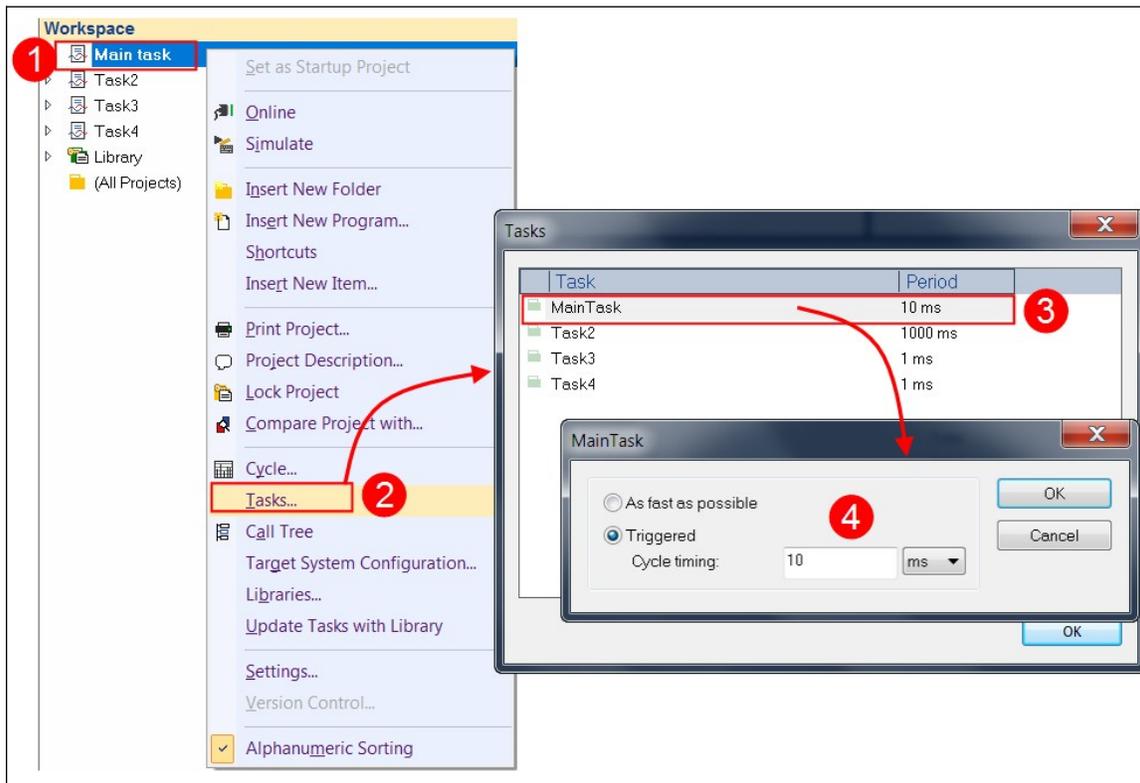


Figure 15: Task cycle time configuration

The 'Main task' is the first task that is started when the PLC application begins execution. The other tasks has to be started from the 'Main task' by calling the SYSSTARTTASK() function. Additional functions are available for configuring and terminating each task within the PLC program (Figure 16).

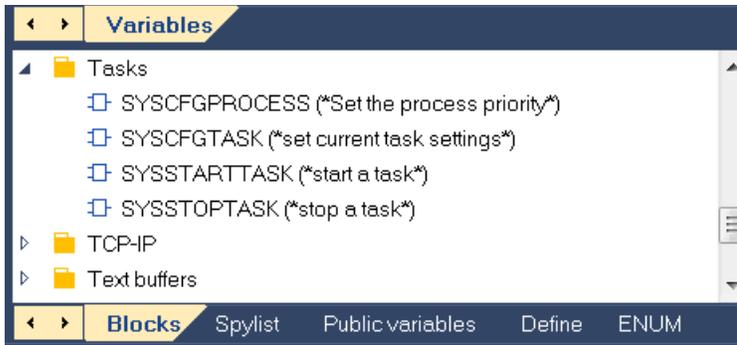


Figure 16: Task dedicated functions

The task library provides the function for configuring and controlling a task:

- To start another task:

```
SYSSTARTTASK( Task(*DINT*), Warm(*BOOL*) )
```

This function should only be called once for starting a task.

- To stop a running task:

```
SYSSTOPTASK( Task(*DINT*) )
```

- Configure a running task:

```
SYSCFGTASK( Prio(*DINT*), Opts(*STRING*) )
```

This function should only be called after a task has been started. It sets the task priority inside a running task.

SYSSTOPTASK( Prio )		
Thread Priority Level	Prio	Description
THREAD_PRIORITY_IDLE	0	
THREAD_PRIORITY_LOWEST	1	
THREAD_PRIORITY_BELOW_NORMAL	2	
<b>THREAD_PRIORITY_NORMAL</b>	3	
THREAD_PRIORITY_ABOVE_NORMAL	4	
THREAD_PRIORITY_HIGHEST	5	
<b>THREAD_PRIORITY_TIME_CRITICAL</b>	6	Default task priority setting of the Win-GRAF runtime

The `SYSCFGTASK` internally calls the `SetThreadPriority()` Windows API to adjust its priority relative to other threads in the process. To keep the priority setting simple it is suggested to just select between `THREAD_PRIORITY_NORMAL` for the normal task and `THREAD_PRIORITY_TIME_CRITICAL` for the high priority task.

Opts:

This parameter is not supported by the Win-GRAF PC-Runtime. Therefore just enter an empty string ( ' ' ).

- Set the priority classes of the process. This is a Windows-related runtime process priority setting.

`SYSCFGPROCESS( Prio(*DINT*) )`

This setting is only in rare cases necessary. By default the process priority is set to 'HIGH\_PRIORITY\_CLASS'.

Windows supports the following priority classes:

SYSCFGPROCESS( Prio )		
Priority Classes	Prio	Description
IDLE_PRIORITY_CLASS	0	
BELOW_NORMAL_PRIORITY_CLASS	1	
NORMAL_PRIORITY_CLASS	2	
ABOVE_NORMAL_PRIORITY_CLASS	3	
<b>HIGH_PRIORITY_CLASS</b>	4	Default setting of the Win-GRAF runtime
REALTIME_PRIORITY_CLASS	5	

The white field in Table 1 shows the task priority value for the combination of process class and thread priority setting. The priority setting for each running task is shown in the 'Win-GRAF Runtime Utility' (Figure 17).

SYSSTOPTASK( Prio )		SYSCFGPROCESS( Prio )					
Thread Priority Level (THREAD_PRIORITY_)	Prio	IDLE_PRIORITY_CLASS	BELOW_NORMAL_PRIORITY_CLASS	NORMAL_PRIORITY_CLASS	ABOVE_NORMAL_PRIORITY_CLASS	HIGH_PRIORITY_CLASS	REALTIME_PRIORITY_CLASS
		0	1	2	3	4	5
IDLE	0	1	1	1	1	1	16
LOWEST	1	2	4	6	8	11	22
BELOW_NORMAL	2	3	5	7	9	12	23
<b>NORMAL</b>	<b>3</b>	<b>4</b>	<b>6</b>	<b>8</b>	<b>10</b>	<b>13</b>	<b>24</b>
ABOVE_NORMAL	4	5	7	9	11	14	25
HIGHEST	5	6	8	10	12	15	26
<b>TIME_CRITICAL</b>	<b>6</b>	<b>15</b>	<b>15</b>	<b>15</b>	<b>15</b>	<b>15</b>	<b>31</b>

Table 1: Task priority

The screenshot shows the Win-GRAF Runtime Utility interface. The 'Status' tab is active, displaying a table of task configurations. The 'Task Priority' column is highlighted with a red box. The table contains the following data:

Task #	Name	Threa...	Tas...	Set C...	Rea...	Exe Time [ms]	Max Exe Time [ms]	Exe Cycles	Overflow	Task Priority	Dwld Port	PLC File Foun
Task 1:	MainTask	RUN...	RU...	10.000	15...	0.017	0.290	4369	0	15	1100: OPEN	"t5_1.cod"
Task 2:	Task2	RUN...	RU...	1000...	999...	0.014	0.312	69	0	1	1101: OPEN	"t5_2.cod"
Task 3:	Task3	RUN...	RU...	1.000	0.0...	0.003	0.465	10630413	0	15	1102: OPEN	"t5_3.cod"
Task 4:	Task4	RUN...	RU...	1.000	0.0...	0.005	0.246	10625560	0	15	1103: OPEN	"t5_4.cod"

At the bottom of the window, the status bar shows: APPLICATION: RUNNING, RUNTIME LICENSE: VALID.

Figure 17: Runtime task priority setting

---

## 6 Runtime Auto-Start

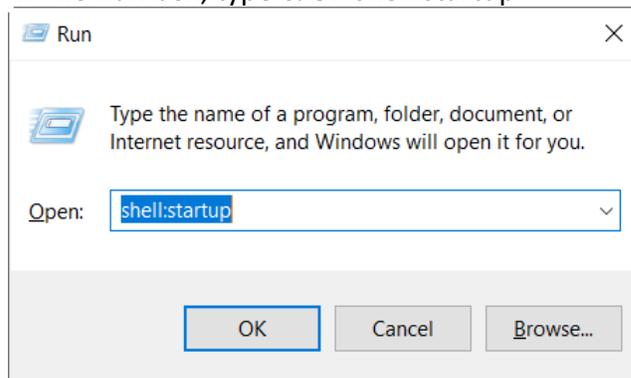
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Windows OS provides a auto-start functions which automatically starts specified execution files on system start. For this purpose a dedicated startup directory is provided in which the system administrator has to add the shortcut links of all the execution file which needs to automatically start directly after the Windows OS starts.

The following steps describes the procedure for configuring the program auto-start function:

**Step 1:** Open the Windows Startup folder:

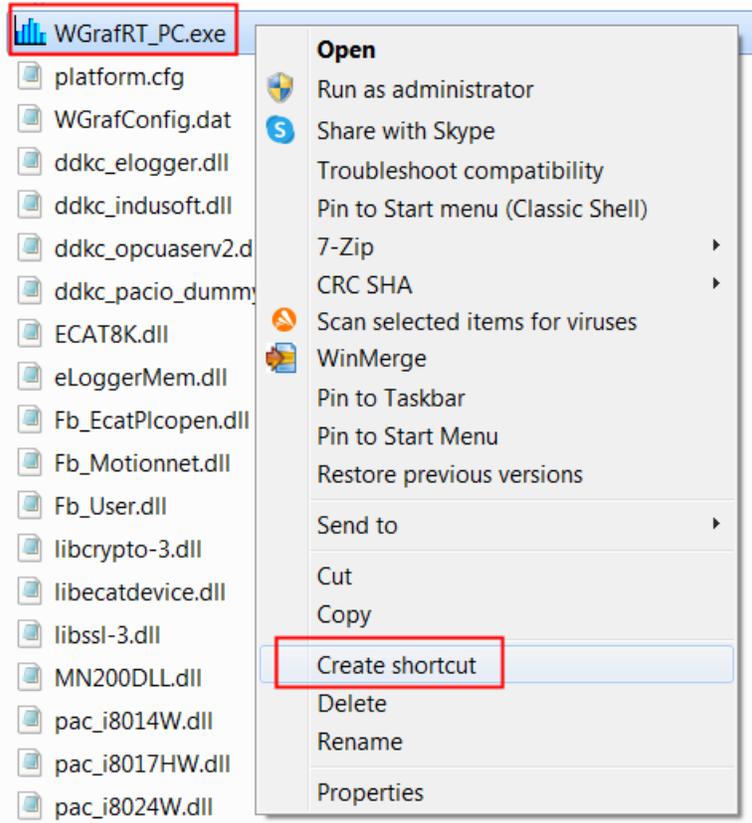
- i. Open the Run dialog. To do this either right-click on the Start Menu flag and left-click Run. Or use the keyboard shortcut *Windows Key & R*.
- ii. In The Run box, type & OK shell:startup



The windows Startup folder will open.

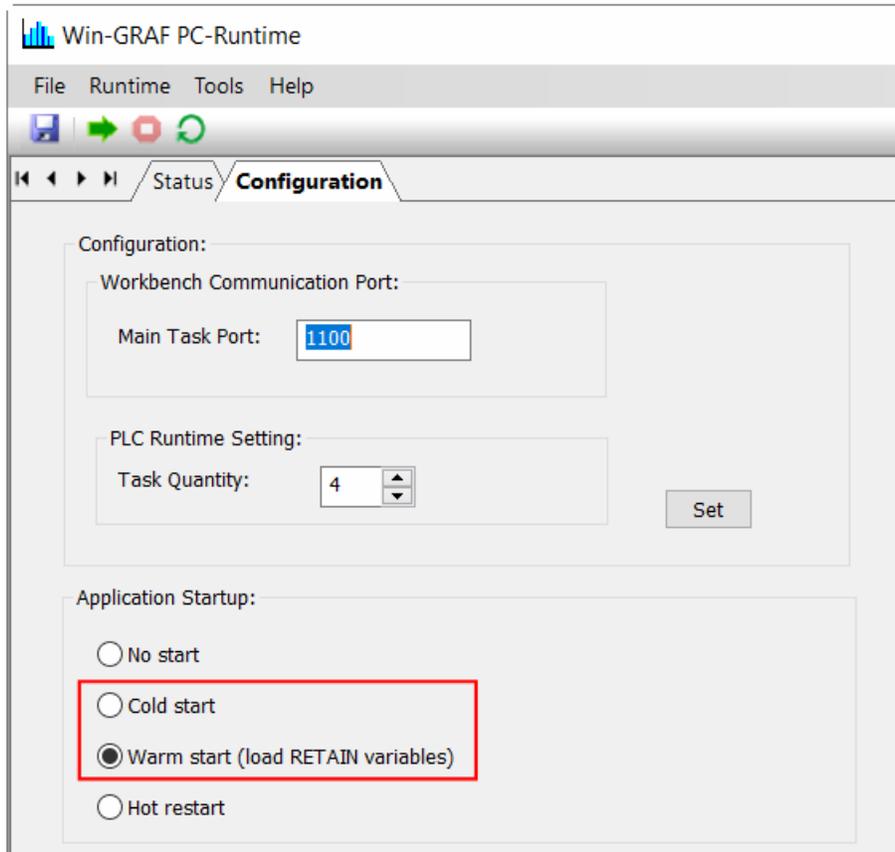
**Step 2:** Create a '*WGrafRT\_PC.exe*' shortcut file and copy this file into the '*Startup*' folder

- i. Right click the '*WGrafRT\_PC.exe*' file and select '*Create shortcut*'



- ii. Copy the shortcut file '*WGrafRT\_PC.exe - Shortcut*' to the Windows '*Startup*' folder

**Step 3:** Start the '*Win-GRAF PC-Runtime Utility*' and enable the '*Automatically start PLC runtime at program start*' checkbox to automatically start the runtime with the PLC application directly after Windows start. If this check box is not enabled only the utility will automatically start but not the runtime. Save the setting by clicking the '*Save*' button



Whenever you boot your computer up, the runtime with the PLC application automatically will run. To remove it from startup, simply delete the Win-GRAF Runtime shortcut file from the 'Startup' folder.

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## 7 Activate “Lock Screen”

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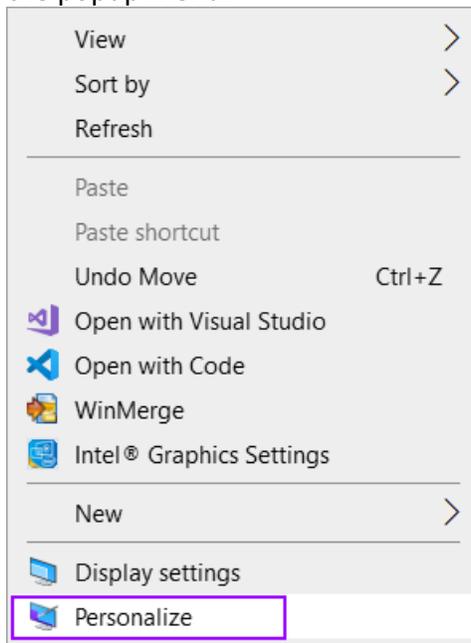
To prevent unauthorized persons from accessing and manipulating the Win-GRAF runtime while the PLC application is running, it is strongly recommended that you protect your computer:

1. Set the password for the operating system.
2. Activate the screen lock automatically.

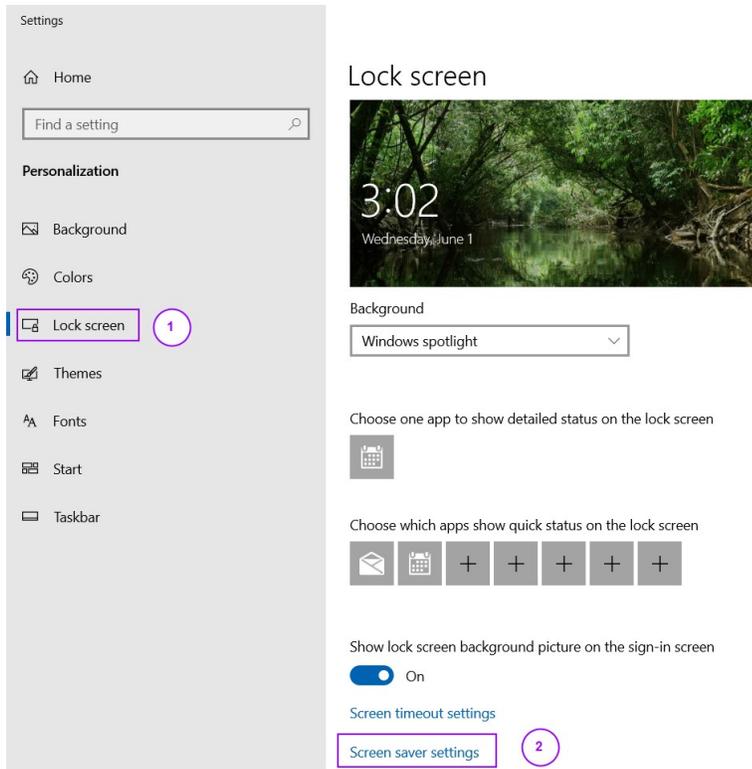
Enabling automatic screen lock prevents people from tampering with runtime settings. The screen can only be unlocked by entering the operating system password (e.g. User Account password)

Steps for activating the screen lock functions:

**Step 1:** Right-click on an empty place on your desktop and select '*Personalize*' from the popup menu.

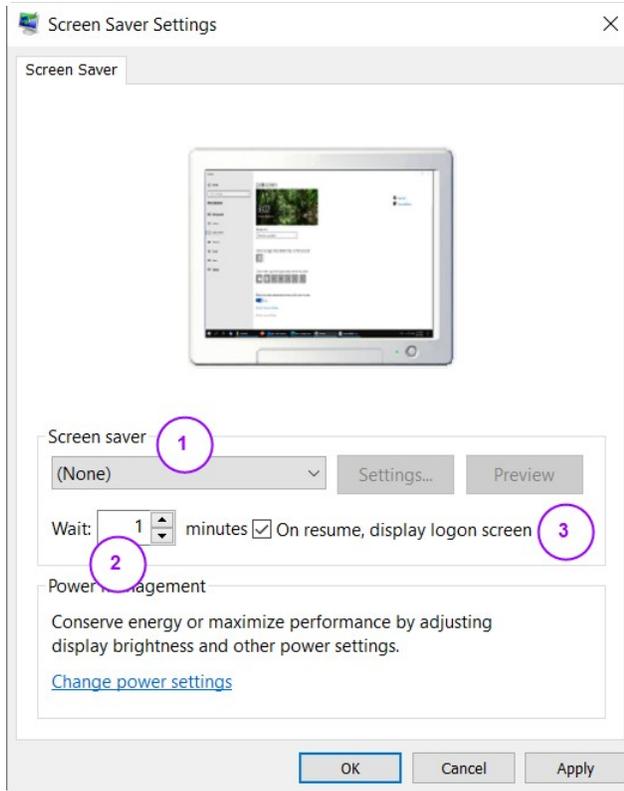


**Step 2:** From the side menu select '*Lock Screen*' and click '*Screen Saver Settings*'



**Step 3:** Set Screen saver:

- i. Choose the type of screen saver.
- ii. '*Duration*': The '*Wait*' option sets the number of minutes of inactivity before the screen saver turns on. The lowest wait time is one minute
- iii. '*On resume, display logon screen*': If this option is enabled, your device will automatically lock when the screen saver activates. It is necessary to enter the user password to unlock the screen saver.
- iv. Confirm the setting with '*OK*'



The Win-GRAF runtime continues to run regardless of whether the screen saver is displayed or not. Even a password-protected screen saver has no influence on runtime execution.

The screen saver is activated and appears after the set time has elapsed. If you want to display the screen saver immediately when you leave the device, press the key combination:

'Windows Logo'  key + 'L' key