SoftPLC Hot-Backup System
User's Manual
(for versions 4.6 and later)

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SoftPLC Corporation 25603 Red Brangus Drive
Spicewood, Texas 78669
Telephone: 1-800-SoftPLC (US/Canada) 512-264-8390
Fax: 512/264-8399
URL: http://softplc.com
Email: support@softplc.com

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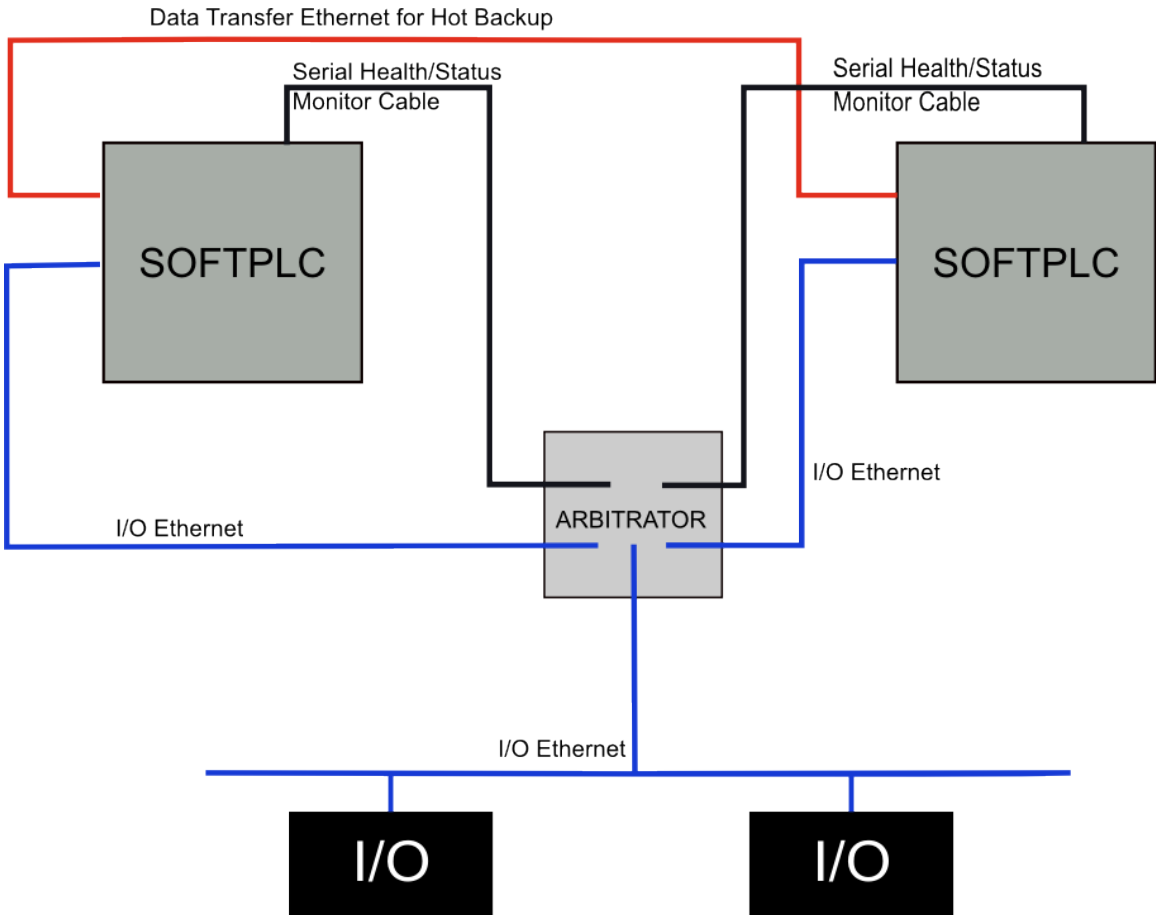
1 Overview

This document describes the features, operation, and usage of the SoftPLC Hot-Backup system for runtime firmware versions 4.6 and later. This system provides operational redundancy with "bumpless" transfer of I/O control between SoftPLC CPU's if a control-switch related event occurs. The content in this document assumes the user already has general familiarity with SoftPLC equipment and software.

The Hot-Backup system includes both software and hardware components. The software component is a TOPDOC Loadable Module (TLM) which operates as an extension to the SoftPLC runtime engine. This **HOTBACK** TLM manages the Hot-Backup related activity of the SoftPLC CPU. The hardware components immediately relevant to the system include two SoftPLC CPU with the HOTBACK TLM installed and an intermediary device called the **Arbitrator**.

*(**NOTE:** This system replaces the Tealware Hot Backup System which required the SPLC-2 CPU and BACK10 modules, and SoftPLC versions 2.x through 3.x)*



Example Configuration Using Ethernet I/O

1.1 Definitions

- master - used to describe the unit/role that is "in charge" of the overall system and that is actively communicating with I/O
- backup - used to describe the unit/role that is "idle" in the overall system and is remaining synchronized with the master
- configured role - describes the master/backup role assigned to a SoftPLC CPU in the HOTBACK TLM configuration
- active (or current) role - describes the role that the SoftPLC CPU is currently performing in context of the Hot-Backup system
- peer - used to describe the "other" SoftPLC CPU in the Hot-Backup system

1.2 Concepts

1.2.1 TLMs

The **SoftPLC runtime engine** software supports TLM's, which are shared library extensions to SoftPLC. A TLM may be loaded either as a **DRIVER** or as a **MODULE**. The difference between a DRIVER and a MODULE is that a DRIVER is called once per SoftPLC scan, and optionally an additional number of times per scan. A MODULE is only called when the control program decides to call it and not as an inherent part of the scan. TLM's are made known to SoftPLC in the MODULE.LST file which may be edited by **TOPDOC NexGen** by traversing to: **PLC | Modules**.

Note: *The HOTBACK TLM is a DRIVER.*

1.3 Hot-Backup Roles

Master Role: The SoftPLC which is the current master performs the normal duties of a SoftPLC. Additionally, it sends a copy of the mirrored regions of its datatable image to the current backup each scan after solving the ladder.

Backup Role: The SoftPLC which is the current backup also solves the ladder on each scan, but does not write to the I/O. After solving the ladder, it receives the most recent mirrored datatable image from the master and writes the received values into its datatable. Therefore, the backup is solving ladder for the same values as the master on each scan, delayed by one scan.

1.3.1 Hot-Backup-Aware TLMs

In order for the HOTBACK TLM to work, any other TLMs active on the SoftPLC must be designed with support for the Hot-Backup system. Specifically, they must not write to I/O when the SoftPLC's Operating Mode is set to a backup-role related mode. Contact SoftPLC for details if you need to add Hot-Backup support to your TLM.

Hot-Backup Aware TLMs provided by SoftPLC include: Modbus TCP Master (MBIPMAST.TLM)

1.3.2 Arbitrator

The Arbitrator is a "dumb" hardware device which functions as a pass-through (or disconnect/ block) for the communications from the SoftPLC processors to the remote I/O. The Arbitrator ensures that only one unit will be able to control the I/O. One example of a situation where the Arbitrator steps in is in the event that the two Hot-Backup SoftPLCs lose communications (e.g. the Ethernet cable between them is disconnected or fails). Other cut-off scenarios occur in the Arbitrator based on the inputs it receives from the two Hot-Backup SoftPLCs. As long as the Arbitrator is told that the two CPUs are in agreement (and of course for that to be the case they must be communicating with one another directly), then the Arbitrator will not typically step in and assert itself.

In the event of complete loss of input or power loss to the Arbitrator, it will enter a fail-safe operating condition to always allow communications for the SoftPLC connected to the backup ports.

The Arbitrator device also has a toggle switch which allows for a manually forced role switch of the CPUs. Toggling the switch will cause the current master and backup to switch their roles, assuming that the system was operating normally *(some failure status conditions will cause the switch to be ignored).*

1.3.3 Supported Datatable Mirroring

The SoftPLC Hot-Backup system supports mirroring of a number of datatable files.

Always Mirrored:

- Digital inputs file - O0
- Digital outputs file - I1

Optionally Mirrored:

- Analog inputs file - integer type, typically N7
- Analog outputs file - integer type, typically N17
- Counter file - typically C5
- Timer file - typically T4
- Float file - typically F8
- PID file - typically PD9

The optional files are specified in the HOTBACK.LST configuration file for the HOTBACK TLM. Details on this configuration file are discussed in the section Configuration / Setup.

1.4 Requirements

1.4.1 Hardware

- Two SoftPLC CPUs, one to be the normal master role and one to be the normal backup role
- The Hot-Backup system Arbitrator
- Ethernet Cable for “hot-backup”, ie: master to backup communications
- Ethernet Cables from CPU to Arbitrator for I/O communications (2)
- Serial Cables from each CPU to Arbitrator for health monitoring communications (2)
- (2) 24VDC power supplies, which are hardare “OR-ed” in the Arbitrator for use by both CPU's
- Power Cables
- Ethernet Cable from Arbitrator to I/O drops/devices

1.4.2 Software

- Gatecraft Linux version 4.6 or above
- SoftPLC runtime version4.6.20130621 or above
- HOTBACK TLM
- TOPDOC NexGen version1.6.20130619 or above *(optional)*

2 Installation

The TLM is **hotback.tlm.so**, and the configuration file is **HOTBACK.LST**. You will need to copy both of these onto the SoftPLC into the /SoftPLC/tlm directory. To add your TLM to TOPDOC NexGen to enable it for use with offline editing, copy the hotback.tlm.so file into your /SoftPLC/tlm/ directory *(wherever you have installed TOPDOC NexGen).*

To enable the TLM within the SoftPLC's, use **TOPDOC NexGen.** Traverse to **PLC | Modules** and select *Use* for HOTBACK.TLM. Click the *Configure* button to edit the HOTBACK.LST file *(note that editing the configuration file in this manner requires a connection to the SoftPLC).*

To enable the TLM by editing the MODULE.LST file directly, add the line below to the file /SoftPLC/run/MODULES.LST.

```
DRIVER=/SoftPLC/tlm/HOTBACK.TLM
```

3 Configuration / Setup

3.1 TLM Configuration

The configuration file for the HOTBACK TLM is **/SoftPLC/tlm/HOTBACK.LST**. The default file is shown below - the comments in the file explain the format.

```
# Configuration file for SoftPLC HOTBACK TLM.
# Anything from # to end of line is a comment.

# The configured role for the SoftPLC under HOTBACK.
configured_role = master        # master or backup

##############################################################################
# The specification for the datatable files to be mirrored. These are in addition
# to the I1 and O0 digital input/output files which are always mirrored.
# The element specified currently has no real effect. The entire file is always
# mirrored.
# It is also important to note that no files outside the ones specified here are
# supported. This means that you cannot duplicate or add to the "xyzfile = "
# entries in the list below.
# All are **OPTIONAL**. Commenting files listed here will reduce the files mirrored
# by the HOTBACK TLM
##############################################################################
#analoginfile = N7:0             # integer file used for analog inputs
#analogoutfile = N17:0           # integer file used for analog outputs
#counterfile = C5:0              # counter file.
#timerfile = T4:0                # timer file.
#floatfile = F8:0                # float file.
#pidfile = PD9:0                 # PID file.

# the system identifier for the ethernet port connecting this HOTBACK SoftPLC
# to the other HOTBACK SoftPLC.
# **OPTIONAL**  Defaults to: eth1
#hotback_eth_id = eth1

# the port number for the serial port connecting the HOTBACK SoftPLC to the
# Arbitrator
# **OPTIONAL**  Defaults to: 1
#serial_port_num = 1
```

Obviously one CPU should have the HOTBACK TLM configured as master and one as backup. The TLM will not allow a transition to RUN mode if there is any issue with configuration.

The mirrored file specifications must include the element number, although it does not have any effect - the entire file is mirrored. The file numbers can be changed as needed to match your usage of the datatable, but the types must match.

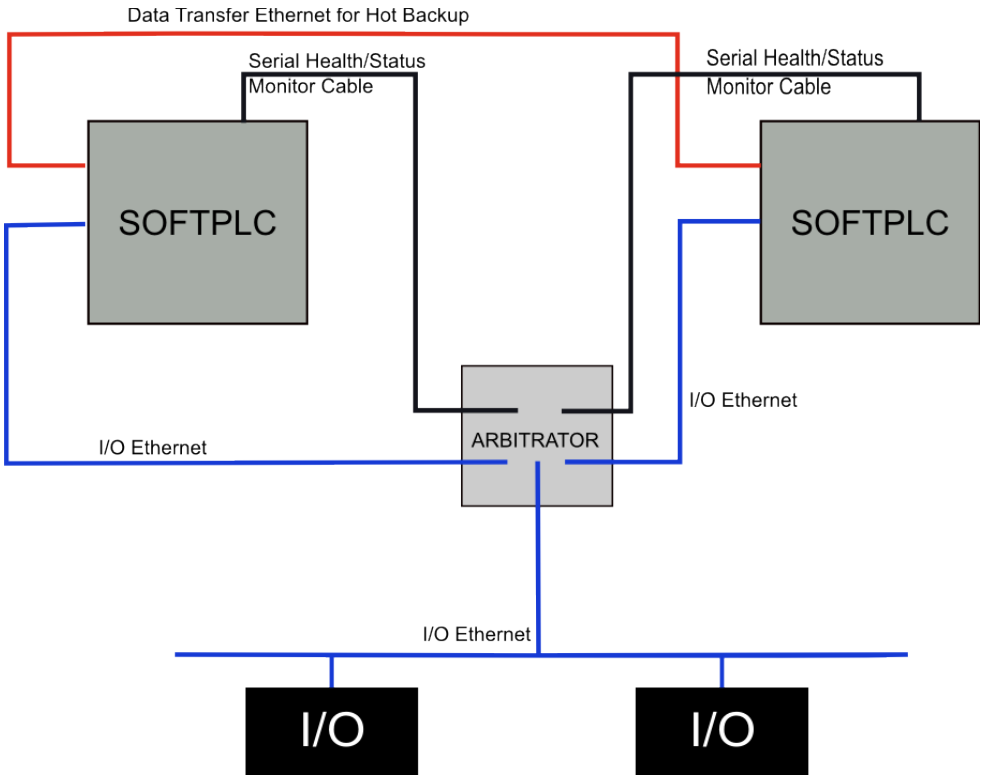
Caution: It is important to note that the files specified must exist in the datatable on **both** SoftPLCs and must be created to be the same size.

3.2 Hardware Setup

The two SoftPLC CPU units are directly connected to each other by ethernet. This connection is used by the HOTBACK TLM for communications to its peer, mainly to monitor the status of the other unit and to send/receive the mirrored datatable elements.

The ethernet connections used to control I/O are connected from each CPU to the Arbitrator, and a single connection from the Arbitrator goes out to the I/O racks.

A serial connection from each CPU to the Arbitrator provides for monitoring health and status information between the two devices. In general, the CPU configured in software as master should be connected to the master ports on the Arbitrator and the CPU configued in software as backup should be connected to the backup ports.



Example Configuration Using Ethernet I/O

If SCADA or HMI devices are normally used in your system, some additional setup considerations may be required to allow the devices to work with the Hot-Backup system. The SoftPLC CPUs will not have identical MAC addresses or IP addresses - this should be adjusted for when setting up the connections if the SCADA/HMI is required to work even in the event of a control-switch to the backup unit.

3.3 SoftPLC APP Setup

3.3.1 Ladder Editing and Datatable Definition

Warning! The ladder programs and datatable definitions (files, file sizes) are **not** synchronized between Hot-Backup CPUs by the HOTBACK TLM. Any I/O drivers in use are also **not** synchronized.

It is the user's responsibility to ensure that these elements are kept in sync by manually performing changes on both units, or copying changes from one unit to the other. With this in mind it should be noted that run-time editing of ladder on one CPU can have unintended and potentially dangerous effects if done in the context of the Hot-Backup system.

3.3.2 Datatable Value Changes

Any changes made to datatable values outside the files defined in the HOTBACK.LST configuration file are **not** synchronized between Hot-Backup CPUs by the HOTBACK TLM. It is recommended that any SoftPLC APPs being designed for use with the Hot-Backup system use only those datatable areas that are synchronized by the TLM.

Note that any changes made to datatable values on the backup will be overwritten on the next scan by the data received from the master.

4 Operational Notes

4.1 SoftPLC Operating Mode

Operating mode changes (REM/PROG, REM/TEST, REM/RUN) should be accomplished through TOPDOC. Note that mode change commands sent to the current backup will be denied. The current master will tell the backup about mode changes and the backup unit will follow by changing its own operating mode appropriately.

4.2 Toggle Switch

The toggle switch on the Arbitrator unit works as described in section 1.3.2. In effect, one position of the toggle switch will cause the two HOTBACK units to attempt to assume their configured roles, while the other switch position will cause the units to attempt to assume the role inverted from their configuration.

Note that the word "attempt" is used in the above explanation because the toggle switch position will not affect the active role of the unit in failure cases. Instead, the units will assume whatever role is necessary to ensure that the I/O continues to be controlled.

4.3 DENY_MASTER Bit

The status bit S17/4 is used as a DENY_MASTER flag for the HOTBACK TLM. If the bit is set, the TLM will refuse to assume the master role if at all possible. This refusal will override the toggle switch. Normally this bit would be set by the active I/O DRIVER to indicate a failure in the Ethernet link to the remote I/O.

The unit will assume (or stay in) the master role even if this bit is set in the case of link failures between the two CPU units, or between the peer and the Arbitrator, or if the peer's DENY_MASTER bit is also set.

The status bit S17/5 is a read-only bit used for the HOTBACK TLM to indicate the value of the S17/4 bit on the peer unit.

4.4 Adaptive Role Switching

The HOTBACK TLM is designed to be as adaptable as possible to startup and link failure conditions.

4.4.1 Power On / Startup Concerns

The Hot-Backup system does not require a specific power on sequence for the hardware units. If one SoftPLC CPU in the system is much faster to start up than the other, it will automatically control the I/O until the configured master unit is fully started and in sync, at which point they will switch roles to their configured settings. If the faster-starting unit is the configured master, obviously no switch will occur.

Note: If the datatable values have only been established on the configured master unit, that CPU should be allowed to fully start up and transition to a (REM)RUN operating mode before starting up the backup unit. This will avoid the set values being overwritten by the blank or otherwise incorrect values on the backup. Alternatively, this can be avoided by ensuring that the datatables are the same before starting or transitioning the units into a RUN mode. The ladder program itself could also be used to initialize the datatable to the correct state.

4.4.2 Power Off

There is not a required power-off sequence for the Hot-Backup system; however, the system will continue to try to run the process and control I/O until both units are powered off. For example, if the active master unit is powered off first, the active backup will see this as a failure condition and take over as master until it is also powered off.

4.4.3 Link Failures

The HOTBACK TLM will automatically change between backup and master roles as appropriate in order to ensure that the I/O continues to be controlled in the event of any link failures. The I/O will only ever receive input from one CPU at a time due to the cutoff behavior of the Arbitrator.

If a failed link is re-established while the system is still running, the units will re-synchronize and assume their correct roles based on the configuration, toggle switch position, and DENY_MASTER bit value.