

# EPICS DRIVER FOR PHOENIX CONTACT REDUNDANT PLC

G. Liu<sup>\*</sup>, C. Li, J. Li, K. Xuan, J. Wang, W. Xu, NSRL, USTC, Hefei, Anhui 230029, China.

## Abstract

The RFC 460R PLC from Phoenix Contact is a high-performance controller that has been extended to offer redundancy functionality. This redundancy functionality is vital for uninterrupted processes in complex systems and large plants. In order to integrate this product into EPICS environment, an EPICS Driver is developed. This driver is intended to connect a pair of RFC 460R redundant PLCs via TCP/IP to an EPICS IOC. In this paper, the communication mechanism, software implementation and the test results of a prototype system will be described.

## INTRODUCTION

The RFC 460R PLC from Phoenix Contact is a high-performance controller that has been extended to offer redundancy functionality. The redundant control system with the RFC 460R PLCs can provide maximum availability throughout the system – from the I/O level to the control level. This is vital for uninterrupted processes in complex systems and large plants[1].

In order to integrate the RFC 460R PLC into EPICS environment, an EPICS driver is developed. This driver is intended to connect a pair of RFC 460R redundant PLCs via TCP/IP to an EPICS IOC. Inspiring from the EPICS driver "S7plc" for Siemens S7 PLCs [2], we adopt the so called "send/receive" protocol to exchange the fixed size data block between the PLC and the EPICS IOC, and put our emphasis on the implementation of redundancy functionality. This EPICS driver, to a certain extent, can be viewed as the special version of the EPICS driver "S7plc" with the redundancy functionality.

In this paper, the communication mechanism, software implementation and the test results of a prototype system will be described.

This driver is tested with Phoenix Contact RFC 460R and ILC 170 under EPICS base R3.14.12.2 and Linux environment.

## COMMUNICATION MECHANISM

The typical redundant control system consists of two synchronized RFC 460R PLCs connected via an optical fiber, as shown in figure 1. The built-in optical fiber interface is used for synchronization and adjustment between the redundant pair. The RFC 460R PLC connects I/O devices via PROFINET.

During initial startup redundancy type FIRST must be assigned to one of RFC 406R PLCs and redundancy type SECOND to the other. The redundancy type does not change during operation. The SECOND PLC always has the IP address of the FIRST PLC increased by 1. The redundancy role of the RFC 406R PLC (i.e. PRIMARY or

BACKUP) may change depending on the status of the redundant control system.

The driver runs as a TCP client, while the PLC runs as a TCP server. When the IOC starts, the driver tries to establish connection to the PLC pair. If connection establishment fails the driver periodically retries. Once successful, the driver waits for the data blocks sent by the PLC. During operation, the PRIMARY PLC sends data blocks to the IOC periodically, but the BACKUP PLC does not send any data to EPICS IOC. This is the rule to distinguish the redundancy role of the PLC. If the PLC sends data blocks, it is the PRIMARY PLC; otherwise it is the BACKUP PLC. The driver only sends data blocks to the PRIMARY PLC. In order to monitor the status of the BACKUP PLC, the driver runs the command "ping" to the BACKUP PLC periodically.

According to the switch-over conditions the redundancy role of the PLC may change. When the PRIMARY PLC changes to the BACKUP PLC, the driver does not receive any data within a configurable timeouts, then the driver considers the communication broken and closes the connection. After a short time it tries to reconnect. Meanwhile, the BACKUP PLC takes over the role of PRIMARY and sends data blocks to the IOC. When the driver gets the data from the new PRIMARY PLC, it will exchange data with the new PRIMARY PLC.

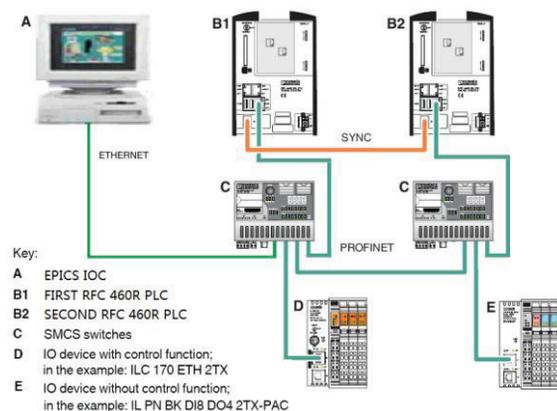


Figure 1: Redundant control system.

## SOFTWARE IMPLEMENTATION

The development for this EPICS driver is based on the EPICS driver "S7plc". In order to let the driver be compatible with the redundant PLC and the normal PLC, we add a flag "redundancy" to the driver configuration function, which is defined as below:

```
phoenixplcConfigure("PLCname", "IPaddr", IPport,
inSize, outSize, bigEndian, recvTimeout, sendInterval,
redundancy)
```

Here, "redundancy" is a flag, "0" means normal mode; "1" means redundant mode, IPaddr and IPaddr+1 are used,

<sup>\*</sup>gfliu@ustc.edu.cn

“IPaddr” is assigned to the FIRST PLC, and IPaddr+1 is assigned to the SECOND PLC.

The following is an mbbi record which is defined to describe the status of the BACKUP PLC:

```
record (mbbi, "$(RECORDNAME)") {
...
field (ZRST, "no partner")
field (ONST, "plc-1st unlinked")
field (TWST, "plc-2nd unlinked")
field (THST, "plc-1st linked")
field (FRST, "plc-2nd linked")
field (FVST, "unknown")
...
}
```

Here, "no partner" means the normal mode, i.e. the flag "redundancy" of the driver configuration function is "0"; "plc-1st unlinked" means that the redundancy pole of the FIRST PLC is BACKUP, and the network connection is not established, e.g. it is off; "plc-2nd unlinked" means that the redundancy pole of SECOND PLC is BACKUP, and the network connection is not established; "plc-1st linked" means that the redundancy pole of the FIRST PLC is BACKUP, and the network connection is established; "plc-2nd linked" means that the redundancy pole of SECOND PLC is BACKUP, and the network connection is established; "unknown" means some uncertain conditions, e.g. during switch-over, the driver is uncertain the redundancy role of the PLC.

### TESTS OF A PROTOTYPE SYSTEM

Figure 2 is the photo of a prototype system. Two RFC 460R PLCs form a redundant pair which is synchronized via an optical fiber. The ILC 170 is a normal Phoenix Contact PLC, and it is used for testing the compatibility with the redundant PLC and the normal PLC. The FL Switch MCS is a managed compact switch which is suited for PROFINET real-time and Ethernet IP applications and supports the management functions. The I/O modules are connected to the FL Switch MCS via network cable. The IOC is also connected to the FL Switch MCS via network cable, however it is not visible in this photo.

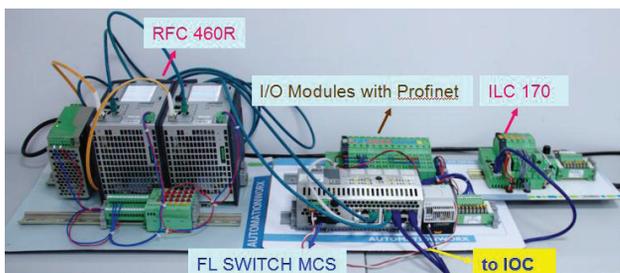


Figure 2: Photo of a prototype system.

Figure 3 to Figure 5 show that the switch-over process of the redundancy role in "PLC-A", "PLC-A" refers to the redundant pair of RFC 460R PLCs, and "PLC-B" refers to the ILC 170 PLC.

At the first step, the FIRST PLC is the PRIMARY PLC, the SECOND PLC is the BACKUP PLC and the network connection is established.

At the second step, we pull out the network cable of the FIRST PLC, then the SECOND PLC takes over the PRIMARY role very quickly, the switch-over time is about 500 ms according to the user manual of RFC 460R PLC. As shown in Figure 4, the SECOND PLC is the PRIMARY PLC, the FIRST PLC is the BACKUP PLC and the network connection is broken.

At the third step, we plug in the network cable of the FIRST PLC. After about 10 seconds ( it is the period the driver monitors the BACKUP PLC status), the network connection of the FIRST PLC is restored, but the FIRST PLC is still the BACKUP PLC.

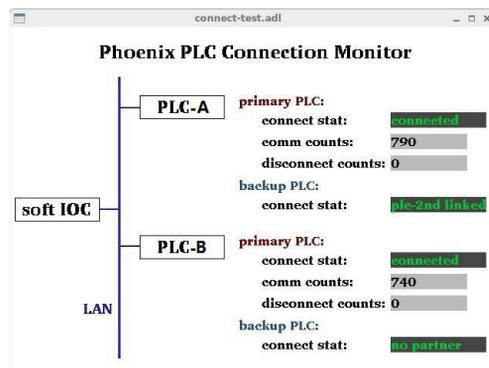


Figure 3: PLCs connection status at 1st step.

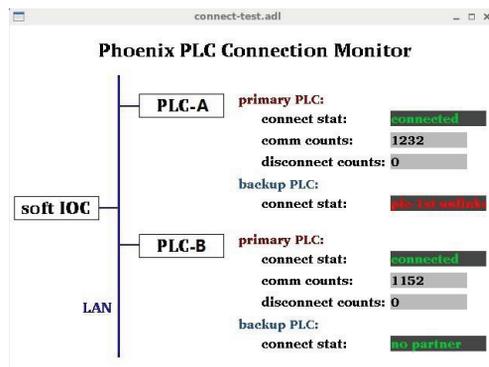


Figure 4: PLCs connection status at 2nd step.

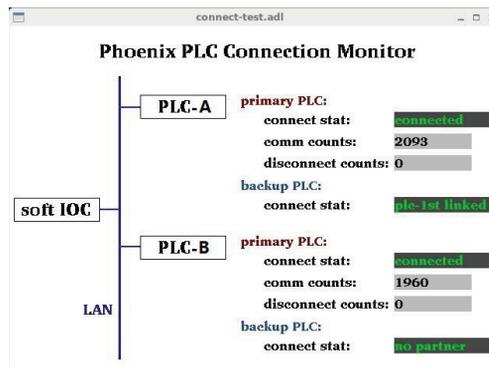


Figure 5: PLCs connection status at 3rd step.

## CONCLUSION

The driver is tested with the prototype system under EPICS base R3.14.12.2 and Linux environment. The test results show that the driver can detect successfully the switch-over of the redundancy role and always exchange the data with the PRIMARY PLC. Moreover, the driver is compatible with the redundant PLC and the normal PLC. The RFC 460R PLC is a good candidate to construct a high available control system.

## REFERENCES

- [1] Phoenix Contact, “User manual: Installing and operating the RFC 460R PN 3TX Remote Field Controller as a redundant control system”, Jul. 02, 2012.
- [2] <http://epics.web.psi.ch/style/software/s7plc/s7plc.html>