Features of IEC 60870-5 Software Libraries

What is IEC 60870-5?

IEC 60870-5 is a general protocol definition developed by the International Electrotechnical Commission (IEC) Technical Committee 57. It is an outline for the structure of a protocol and can only be implemented with a companion standard (profile) to specify options such as one of five link layer formats. Triangle MicroWorks has implemented Source Code Libraries for all of the currently defined profiles: 101, 102, 103, and 104. The 101 profile has been adopted by the Substation Committee of the IEEE Power Engineering Society (1379-2000) as a recommended practice for RTU-IED communication.

What are Triangle MicroWorks, Inc. Software Libraries?

Triangle MicroWorks' Software Libraries provide a cost-effective means of supporting industry-standard protocols in your device. Incorporating our royalty-free Software Libraries in your products will shorten development time, freeing internal resources to work on company proprietary aspects of your products.

Triangle MicroWorks Software Libraries are available in two formats: .NET Protocol Components for incorporation in Windows .NET-based products, and ANSI-Standard C Source Code Libraries for all other platforms.

Features of Our IEC 60870-5 ANSI-Standard C Source Code Libraries

- Written in ANSI-Standard C Source Code, under a strict corporate coding standard.
- Designed to be processor and operating system independent, using any ANSI-Standard C compiler.
- Simple configuration for big-endian or little-endian byte order.
- Can be used with or without a Real Time Operating System (RTOS).
- Database interface supports any database, ranging from direct I/O input with no storage to complex, relational databases.
- Includes sample applications and source code for Low-Level Target Interface for Linux and Windows (see *Design Details for Implementation*).
- Typical product integration times are less than three weeks.
- Easy installation through "Triangle" Source Code Library to Target Application interface (see Design Details for Implementation).

Features of Our IEC 60870-5 .NET Protocol Components

- Based on Triangle MicroWorks, Inc. industry-proven Source Code Library design.
- Supports all .NET Languages (C#, J#, Managed C++, VB .NET, etc.) and tools.
- Compatible with .NET 2.0 Framework.
- Integrates with Visual Studio Help.
- Available as single-use or redistributable with source code.
- Source code version includes corresponding ANSI-Standard C Source Code Library.
- Includes built-in simple database with save/restore capabilities; also supports user-defined database.
- Ideal for quick development of products and tools requiring IEC 60870-5 support.
- Scalable for large implementations.
- Typical product integration time of less than one week.

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Features Common to All of Our IEC 60870-5 Software Libraries

- Supports both balanced and unbalanced link layer configuration using one or two octet address fields.
- Clock synchronization commands using bitmapped time/date information objects are compensated for transmission and processing delays.
- Supports any applicable physical communication network including RS 232/485 and TCP/IP.
- Can be used in event-driven or non-event-driven environments.
- Extensive, built-in (but removable) diagnostics including a ***protocol analyzer*** used to visually decipher protocol messages. The diagnostic and analyzer strings can be directed to any target system display device, even a serial port or RAM buffer.
- Provides support for statistics of communication protocol errors such as bad checksum, incorrect synchronization byte, and invalid frame length to help identify faulty communication lines.
- No royalty fees per unit sold.

IEC 60870-5 Controlled Station (Outstation) Software Library Features

- Interoperability is maximized by making it easy to attach virtually all possible interoperability configuration settings to run-time variables or function calls.
- Supplies data to an unlimited number of host devices through an unlimited number of communication ports.
- Supports Multiple Application Layer ASDU addresses (sectors). This virtual device capability can supply unique database profiles, or database profiles with common components, to host stations.
- Database manager maps randomly organized Target Application data points (binaries, controls, integers, floats, etc.) into IEC 60870-5-101 ASDU type information objects.
- Example Database Interface implementations are provided for testing, illustration, and as templates to be used for developing final Database Interface.
- Fully supports ASDU types with CP24Time2a (24-bit time tag), including proper handling of clock synchronization commands, and through spontaneous clock synchronization responses upon hourly rollover.
- Includes support for ASDU types with CP56Time2a (56-bit time tag). These include ASDU types 30 through 40 defined by the approved "Addendum to IEC 60870-5-101 Concerning the Extension of Time Tags."
- Spontaneous response data can be automatically generated by configurable scans of Target Application data.

IEC 60870-5 Controlling Station (Master) Software Library Features

- An unlimited number of remote devices can be configured on an unlimited number of communication ports, and new remote devices can be added at runtime.
- Communicates with devices on the same communication port that have different ASDU field sizes (ASDU address, cause of transmission, and information address), or with devices on separate communication ports that have different link address sizes.
- Database manager maps received IEC 60870-5 data objects into Target Application data points (binaries, controls, integers, floats, etc.).

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Efficient Installation, Testing, and Verification

Design Objective:

Our primary design objective is to provide our customers with an ANSI Standard C **S**ource **C**ode **L**ibrary (**SCL**) with a **T**arget **A**pplication (**TA**) Interface that can be implemented in less than three man weeks. To accomplish this, our design divides the interface into "entry-points" from TA-to-SCL, and "calls" back into the TA from the SCL.

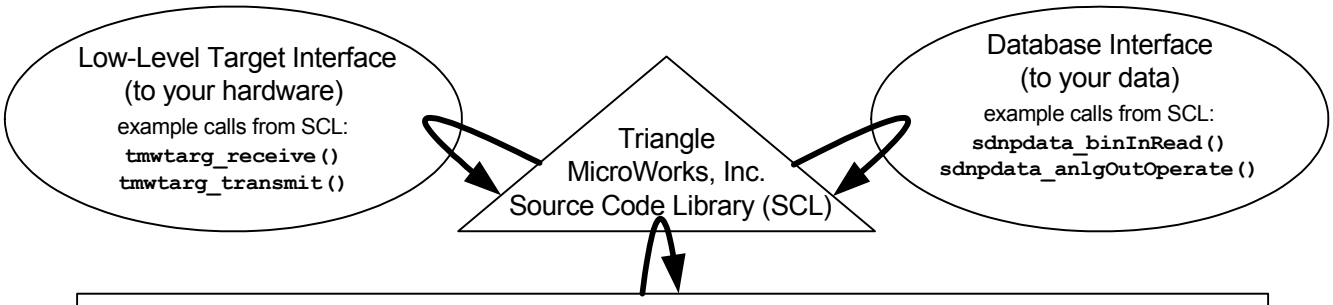
The "Triangle" Approach to Interfacing between the SCL and TA:

The interface between the SCL and TA can be viewed as a three-sided, or "triangle" interface. Two sides represent calls back into the TA from the SCL Interface. Each of these sides is organized into individual, well-documented modules or header files. These files are the only recommended customer-editable (or platform-specific) files. All other files are protocol-specific and should not need to be modified by the customer.

The three sides of the interface are shown in the diagram below:

1) TA-to-SCL Entry Points: The entry points are limited to a few SCL initialization functions and a single process function; the process function can be called regularly as part of a Target Application main loop, or as an event-driven task in a real-time operating system environment. Master Source Code Libraries also provide C function calls to build and send request messages to remote Slave devices.
2) Low-Level Target Interface: Provides access to hardware components such as communication channels, timers, and clocks.
3) Database Interface: Provides customized fit to TA data, and allows extraction and insertion of individual database profiles, including any of our included simulated database profiles used for testing.

Example flow diagram for an installation of the DNP3 Slave Source Code Library



Target Application (TA)
(your mainline software)

```
tmwappl_initApplication()     /* initialize all configuration structures to defaults */
tmwtarg_initConfig();
dnpchnl_initConfig();
sdnpsesn_initConfig();
...                           /* overwrite default config values with user settings */
tmwtimer_initialize();        /* initialize polled timer (if used) */
dnpchnl_openChannel();        /* open channel */
sdnpsesn_openSession();       /* open session */
...
while(1)                      /* begin main loop or task */
{
  ...
  tmwpltmr_checkTimer();      /* if using SCL in polled mode, check timer and */
  tmwappl_checkForInput();    /* check for received data. These lines are not */
  ...                         /* required if using SCL in event-driven mode */
}
```

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Typical Installation Sequence for All Source Code Libraries

We strongly recommend that before you develop any communications protocol, whether or not you use our Libraries, you should create a **C**onfiguration/**I**nteroperability (**C/I**) Guide that conforms to standard "device profile" documents for each protocol. The C/I Guide specifies how to configure the protocol operation of the device; for interoperability, it specifies the objects, variations, and protocol functions that will be implemented. Our Source Code Libraries come with C/I Guide templates, with much of the information already filled in.

After completing the C/I Guide, a typical sequence to install one of our Source Code Libraries is:

1) Edit low-level target interface file to attach serial port receive and transmit functions, add access to a free-running millisecond timer/counter, and to configure byte-order (most or least significant first).
2) Add TA-to-SCL entry point functions in Target Application software (as in the DNP3 example above).
3) Conduct initial testing, which verifies operation of the Source Code Library on the target hardware. Initial testing consists of comparing results of requests and polls with known values from either a simulated database (for Slave Libraries), or from a known slave device (for Master Libraries). Slave Libraries include simulated database profiles with pre-set initial values of database objects; no modification of the database interface is necessary for initial testing.
4) Attach SCL-to-TA calls to your database design by simple replacement of simulated database calls.
5) For Slave Libraries, install report-by-exception processing by adding access to a date/time clock, and configuring scan periods and event buffer sizes.
6) For Master Libraries, install Target Application request messaging by adding calls to build request message entry points from Target Application software.
7) Make final adjustments of the configuration interface to ensure that all user settable configuration parameters are mapped to SCL configuration structures.
8) Conduct final testing.

Testing and Diagnostics

For testing Source Code Library installations, we provide the following tools:

- A ***built-in protocol analyzer*** allows you to visually decipher protocol messages to or from both Master and Slave devices.

Sample Protocol Analyzer display

```
15:28:37.506: ...> slave      05 64 14 c4 04 00 03 00 c7 17

15:28:37.506: ...> slave      ca c9 01 3c 02 06 3c 03 06 3c 04 06 3c 01 06 f8
15:28:37.506:                 ae

15:28:37.506: ---> slave      Primary Frame - Unconfirmed User Data
15:28:37.506:                 LEN(20) DIR(1) PRM(1) FCV(0) FCB(0) DEST(4) SRC(3)
15:28:37.506:                 05 64 14 c4 04 00 03 00 c7 17
15:28:37.506:                 ca c9 01 3c 02 06 3c 03 06 3c 04 06 3c 01 06 f8 ae

15:28:37.506: ~~~> slave      Transport Header
15:28:37.506:                 FIR(1) FIN(1) SEQ# 10
15:28:37.506:                 ca c9 01 3c 02 06 3c 03 06 3c 04 06 3c 01 06

15:28:37.506: ===> slave      Application Header, Read Request
15:28:37.506:                 FIR(1) FIN(1) CON(0) UNS(0) SEQ# 9
15:28:37.506:                 c9 01 3c 02 06 3c 03 06 3c 04 06 3c 01 06

15:28:37.506:                 Object 60(Class Data), variation 2, qualifier 0x06(All Points)

15:28:37.506:                 Object 60(Class Data), variation 3, qualifier 0x06(All Points)

15:28:37.506:                 Object 60(Class Data), variation 4, qualifier 0x06(All Points)
```

- Triangle MicroWorks also offers a Communication Protocol Test Harness to facilitate version release testing of your Source Code Library implementation. The Test Harness acts as a simple Master or Slave device and can also be programmed with automated test sequence scripts. Conformance Test Scripts are also available to perform the conformance test procedures published by the technical committees of each protocol. Please contact us for more information on this product or download a full 21-day evaluation from our website at http://www.TriangleMicroWorks.com/downloads.htm.