Benefits of using the MOSCAD as an RF modem with third party PLCs

1. INTRODUCTION

Supervisory Control and Data Acquisition **(SCADA)** systems designers sometimes consider using radio communication, simply by utilizing the same protocol that they have already used before with wire-lines. However, one must realize, that when the media to be used is radio (whether VHF, UHF, 800/900 MHz, conventional or trunked network), the SCADA system must utilize a specifically adapted RF modem and protocol, which is suitable for that media.

The most critical reasons for this requirement is, that in data communications over radio channels, several users/data terminals share the same frequency channel. In addition, radio channels are always subject to natural interference, which cause errors in the received messages. In order to assure proper operation of the SCADA system, these errors need to be quickly and efficiently corrected. This can only be done with the use of a protocol adapted for radio.

2. RADIO COMMUNICATION VIA FSK MODEM

In a simple point-to-point conventional radio system between RTUs and SCADA central, one may use any third party radio, combined with an **FSK** (Frequency Shift Keying modulator (audio tones for "0" and "1"). The user may expect fairly good results, subject to three basic limitations:

- The frequency channels are dedicated for use only as an RF link between the Remote Terminal Units **(RTU)** or Programmable Logic Controller **(PLCs)** and the Master Control Center **(MCC)**.

- The signal to noise (S/N) ratio of the received signal is high to assure very low Bit Error Rate **(BER).** This has to be verified for every site.

- The messages between the RTUs and the MCC are very short, thus repeated packets will get through without new errors.

If the above listed conditions are met, one may use any FSK modem with any PLC or RTU. Most such modems are capable to communicate via RS-232 link and use a standard FSK modem for polling the remote sites (and transmitting and receiving messages).

It should be noted, that in such a data communications concept, all "protocol related" tasks and functionalities (such as acknowledgment of messages, networking over radio, error handling, "store & forward" of messages on a single channel, etc.) must be done by the RTU or the MCC as part of its "application". As a result, the application programmer will have to address these issues, and actually “program” all these network communication related functions into each RTU.

3. USE OF MOSCAD RF MODEM FOR RTUS / PLCS

The following concept outlines an advanced solution, in which third party RTUs or PLCs may be combined with the MOSCAD CPU. In this case the MOSCAD will not work as a complete RTU but only as a smart RF Modem, serving as a communication vehicle for the system. The MOSCAD implements an Open Systems Interconnection (**OSI)** based seven layer protocol, which ensures high quality RF communications. This concept is recommended by the International Organization for Standardization (**ISO**) for communications.

With this concept, the SCADA MCC communicates with the RTUs by using the Motorola Data Link Communications **(MDLC)** protocol. The MDLC is a seven layer protocol and it is especially optimized for SCADA using conventional and trunked radio channels as well as lines, fiber-optic and other media.

Use of the MOSCAD as RF modem has major advantages in comparison with use of PLCs or RTUs with Multiple Address System (MAS) type radio. The reason is that MAS do not provided any network services, which will have to be handled by the RTU. Refer to **Appendix A** for a description of the MDLC features.

The configuration described in paragraph 2 above (connecting PLCs to microphone/audio input of the radio), may utilize FSK modulation at relatively low speed. The MOSCAD is a more versatile modem and it accommodates several other modulation standards such as: **DQPSK** (Dual Quadrature Phase Shift Keying and **DFM** (Direct Frequency Modulation).

Use of these techniques instead of the simple FSK optimizes data throughput and allows communication over several media (which may be combined into an integrated network).

In comparison to FSK, DFM modulation allows higher data rate on conventional channels, while DQPSK modulation provides better results over certain trunked radio systems.

Figure 1. shows a concept in which the MOSCAD CPU is used as an RF modem in connection with an 3rd party RTU or PLC.

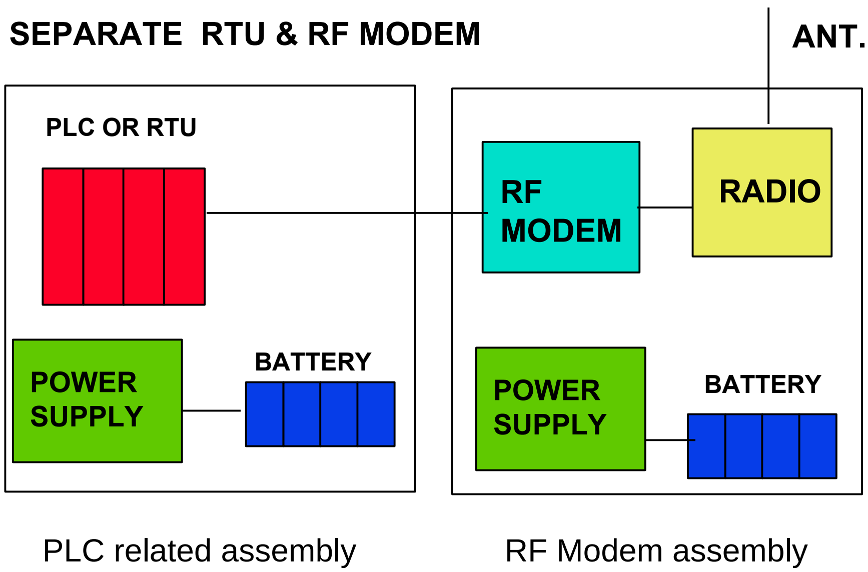

Fig. 1. Use of RF Modem with PLC

4. MOSCAD ACTING AS PROTOCOL CONVERTER

The following operating concepts outlines two separate possibilities where the MOSCAD CPU is connected with third party RTUs or PLCs.

4.1 MOSCAD as a transparent RF modem

This is a quite simple configuration, where the MOSCAD CPU acts as a transparent modem. The MCC and the RTU/PLC are connected to a pair of MOSCAD CPUs, which encapsulate/ de-capsulate the RTU/PLC native protocol. (The MOSCAD transmits the Motorola MDLC protocol over the air).

The MOSCAD is transparent to "its users" and does not interfere with the PLC which handles the actual application (monitoring, alarms, control, etc.). Such encapsulation means, that the original data protocol is "wrapped" by the MDLC protocol, which is transmitted between the ends of the link. See Fig. 2

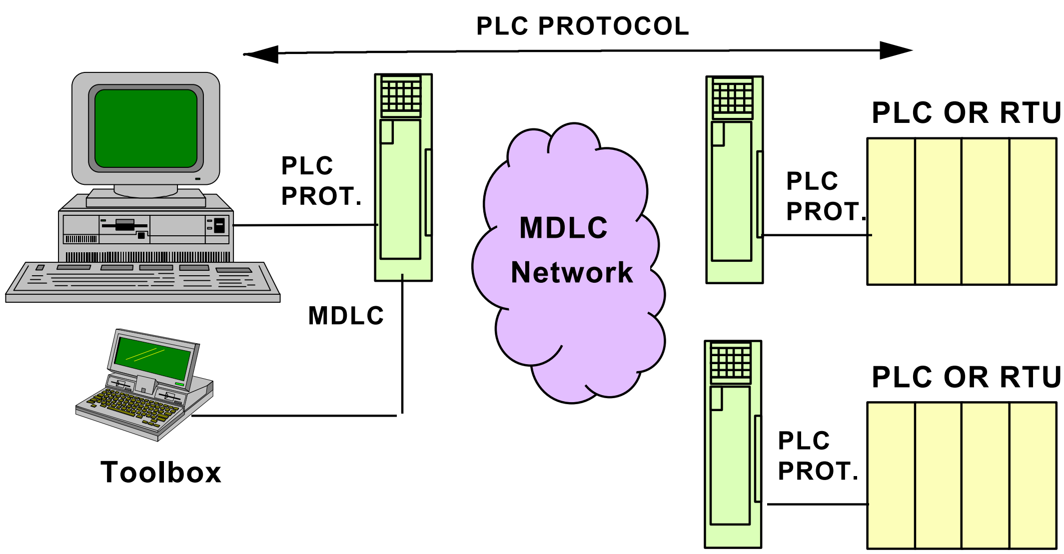

Figure 2 Protocol Encapsulation with MOSCAD

The important issue is that the MOSCAD CPUs on both ends of the link do not hold any data-base, but operate similarly to a line modem. However, all the protocol related tasks such as networking, error detection, message retries and correction are done by the MDLC protocol.

The effective data rate is affected by the following:

* Basic data rate of the selected PLC or RTU and rate of the radio channel
* Message retries caused by the channel
* Length of the messages (over-head bits)
* Existence of Store and Forward repeaters along the link

4.2 Protocol Emulation with MOSCAD

This is a more powerful configuration. Two MOSCAD CPUs are still used, one at the site of the MCC and the other at the RTU site. The difference is, that in this case the MOSCAD CPU holds a data base image of the local terminal (MCC and RTU). The benefit is provided by more efficient air-time utilization and more reliable operation of the system. See Fig 3.

* The MOSCAD CPU at the MCC acts as a Front End Processor **(FEP)** and performs all the data management functions with the MOSCAD CPUs located at the field sites. The MCC communicates with the FEP using its own protocol (this can be either MDLC or the PLC protocol).

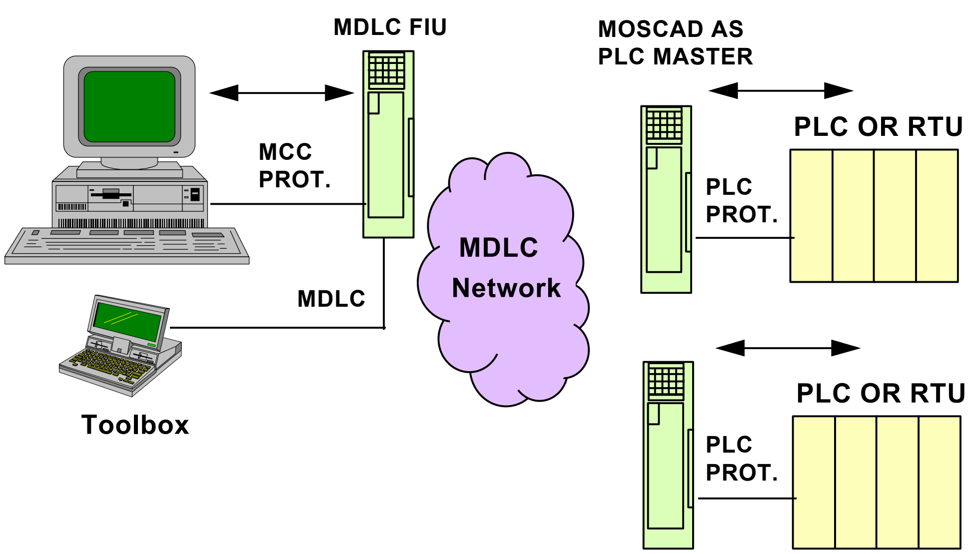

Figure 3. Protocol Emulation with MOSCAD

The field PLCs/RTUs are polled by their local MOSCAD CPUs by using their native data protocol, and the data is stored in the MOSCAD data base. If the MOSCAD detects "changes of state" it initiates transmissions to the other MOSCAD at the MCC location in a contention mode, using MDLC's channel access procedure that minimizes the probability of collision on the RF channel.

5. CONCLUSIONS

Implementation of the MOSCAD as a MDLC based **smart modem**, enhances the performance of the entire whole system, especially when the required medium is RF. In comparison with the use of a line type protocol combined with Multiple Address System (MAS) both the emulation and protocol encapsulation concepts work well even in complex SCADA systems.

Appendix A

The following is a list of MDLC unique features and benefits:

Application processes The project engineers use the MOSCAD ToolBox in order to develop, maintain and modify their RTU application processes. Then they can transfer the program over the air using the MDLC protocol from-or-to all the RTUs installed at the designated remote sites.

Variable length words The MDLC provides the MOSCAD RTUs with very efficient communications methods, allowing to transmit variable length words (messages) between RTUs and between RTUs and the SCADA centrals.

File Transfer The MDLC protocol allows upload and download of all types of data including free format files. This can be directly performed between all the sites, i.e. between the RTUs and between the RTUs and the SCADA central.

Short Messages The MDLC supports efficient transmission of short messages (bursts). This is done without actually creating a communications session (dialogue) between the transmitting and receiving sites.

Remote Diagnostics The MDLC protocol provides service technicians with an option to remotely perform diagnostics of the RTU hardware and software from any RTU site or from the central location.

Remote Calibration The MDLC protocol allows service technicians to perform calibration of the analog ports on any MOSCAD RTU in the network from any remote site, or from the central location.

RTU to RTU links The MDLC protocol supports direct RTU-to-RTU links for sending databases, local statuses and analog values. This can be done directly or via any number of RTUs which act as communications nodes.

Process debugging

The MDLC protocol allows to remotely monitor and debug the local application programs running in the RTUs. If required, the local process in a certain RTU may be updated without actually disturbing the system's operation.

Error logging

Unusual/occasional events are logged in a local error logger in the RTU. The logged historical events may be later retrieved via the network for post mortem analysis.

Error Correction

The MDLC protocol is equipped with a 32 Cyclic Redundancy Code **(CRC)** based error detection mechanism. Upon error detection, the receiving RTU asks the other side to resend only the damaged or missing frames, rather than the entire message frame. In order to save computer time for the process, the CRC calculation is performed by hardware.

Statistical data

The MDLC allows remote access to each RTU (via the communications network) from any location, in order to obtain statistical data on the operation, events, parameters and processes at any of the designated sites.

Mixture of media

The MDLC protocol allows efficient integration of several communication media such as radios, lines, microwave, fiber optics, into single data network while optimizing the overall performance of the system's operation.

Store and Forward

The MDLC protocol supports use of the MOSCAD RTUs in the network as repeaters for data transmission. These RTUs may perform "store and forward" function (for range extension) by reusing the same channel thus eliminating the need for additional frequencies.

Multiple Control centers

The MDLC protocol support network communications with any number of Master Control Centers (MCC), and sub control centers in hierachial schemes. These MCCs may be linked to the network at any RTU location.

Data reliability

The MDLC protocol provides node-to-node as well as end-to-end data acknowledgment via any number of communication nodes (and media) between the RTUs and between the RTUs, and the SCADA Control Center.

Multiple physical ports

The MDLC protocol supports multiple physical ports (radio, RS-232, etc.) in a single RTU, enabling simultaneous communication via more than one port.

Multiple logical links

The MDLC protocol allows simultaneous communications (Central-to-RTU and RTU-to-RTU sessions) of multiple sessions via the single physical port. The sessions sent via the different logical links do not interfere with each other.

Multiple addressing

MDLC protocol supports: individual RTU addressing and system addressing for broadcasting the same message to a defined group of RTUs.

Address recognition

In order not to waste valuable process time spent on checking addresses of messages not intended for that site, the MDLC supports preliminary hardware screening. This increases the overall throughput in the network.

Multi-tasking operation

The MDLC protocol supports performance of several parallel tasks (local processes and communications) without interrupting the normal operation of the RTU.

Protocol emulation

The MOSCAD provides emulation of other SCADA protocols. This will allow using the MDLC protocol in combination with other SCADA systems by using a Gateway or Bridge connecting between various media.

Use of radio media

The MDLC protocol supports a wide variety of RF channels including conventional (VHF, UHF, 800 MHz and 900 MHz), trunked (VHF UHF 800 MHz and 900 MHz), 900 MHz MAS. Any combination of these and other physical channels may be integrated into a single data network.

Contention reporting

The MDLC protocol supports event reporting in both polling and contention modes. In the latter, the RTU contends for the channel and will send its message only when the channel is available (free). This results in significant reduction in the number of air collisions.

Time tagging

The MDLC protocol is suitable for electric Distribution Automation systems, since these require support for system-wide time synchronization (RTUs, communications and Control Center) with an accuracy down to 1 millisecond.