Case Study – NCS-07

V.26 Soft Modem

Introduction

For the last fifteen years the Los Angeles Department of Public Works (LADPW) have used proprietary V.26 (See V.26 Alternative B Overview side-panel) voice-band private wire modems to remotely monitor the water levels of various ground water recharge spreading basins along the Los Angeles river. This monitoring is critical at times of high rain fall to ensure that localised flooding is kept to a minimum.

During this time the network has expanded to allow monitoring of additional information such as the status of outlet and inlet valves and the occupancy or break-in of associated buildings. The original modems were standalone systems that have provided exceptional service for all these years but they have been getting quite old and are no longer available.

The LADPW have considered many options for upgrading the system but, as a public body, they are required to work within tight financial constraints that have precluded replacing the old system with a completely new one.

As part of their evaluation phase, the LADPW contacted Numerix about the possibility of us being able to provide a library of completely integrated soft-modem functions to replace the ageing hardware solution. The software solution was one of many that were considered but it had the key benefit that the soft-modems could operate on standard desktop Personal Computers to reduce costs and increase flexibility.

This case study discusses the project and how the capabilities of the software solution that was developed spawned a whole range of new opportunities for the LADPW to re-use this technology in the future.

<table>
<thead>
<tr>
<th>Data Bits</th>
<th>Phase Transitions</th>
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<tr>
<td>00</td>
<td>+45°</td>
</tr>
<tr>
<td>01</td>
<td>+135°</td>
</tr>
<tr>
<td>11</td>
<td>+225°</td>
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<tr>
<td>10</td>
<td>+315°</td>
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V.26 Alternative B Overview

V.26 Alternative B uses \( \pi/4 \) Differential Quadrature Phase Shift Keying. \( \pi/4 \) DQPSK modulates two bits per symbol and uses the following phase transitions for the data:

One of the benefits of differential encoding is that the demodulation is simpler because it uses the differences in the carrier phase rather than the absolute phase values.

V.26 uses the following frequencies:
- Data rate - 2400 bps
- Baud rate - 1200 Baud
- Carrier freq. - 1800 Hz

A sample rate of 48 KHz was chosen for the test system with a view to reduce this to 12 KHz for deployment to
Implementation Details

The first stage of the project was for Numerix to carry out an analysis of the requirements and submit a proposal for a solution. The proposal was to provide a soft-modem solution based on the SigLib™ DSP library with some additional custom developed functionality. One of the outcomes of the analysis stage showed that there was a lot of commonality between the functionality of the standard SigLib library and the underlying project requirements which this lead to a reduction in the amount of additional software that would need to be developed.

This ability to re-use standard functions from the off-the-shelf library meant that the overall time-to-market and development costs for the project were significantly below the cost of developing a complete soft modem from scratch and as a result of this, Numerix were contracted to develop the software for the project.

In addition to being able to re-use standard functions to reduce the development time, there was another benefit with using the SigLib DSP library as the basis for this project and that was the fact that the library re-compiles and has been tested on a range of different microprocessors and DSP devices. This feature allowed the engineering team at the LADPW to prepare data files, in industry standard .wav file format, from real data sequences recorded in the field over long periods of time. These files were emailed to the Numerix software team who used them to test the soft-modem functions with real world data as they were being developed. Despite the fact that the development and deployment teams were 6000 miles apart this allowed the two teams to work closely together to minimize the development time.

Amongst the many technical details, that had to be considered in this project, were the choices of development languages for the application layer and the modem layer. The LADPW use C# for their development environment because of the ease of development, the power of the language and graphics capabilities. C# includes the ability to link to Windows™ Dynamic Link Libraries (DLLs) which allowed easy integration with the SigLib DSP library that is written in ANSI C and is available as a DLL.
As with any modem, the demodulator is significantly more complex than the modulator due to the requirements to detect the carrier and symbol timing, decode the symbols and perform other data processing tasks (figure 1). This functionality requires that the demodulator incorporates underlying modulators, filters, error detectors and many other low-level functions. While it is perfectly possible to call the core SigLib demodulation functions directly from C#, this would mean that the application layer would be required to manage a large number of arrays and variables so the LADPW engineering team asked for a wrapper layer to be developed that would allow them to simply configure the modulation and demodulation functions without needing to concern themselves with the underlying detail. The SigLib DLL wrapper layer that provides this additional provides this integration for the demodulator is shown in Figure 2. A similar DLL wrapper function was also written for the modulator.

**Figure 2 – The layered approach to integrating the SigLib DLL into the host development environment.**

### The Future

As described in the introduction, the original plan for the project was to replace the central office equipment but the success of the project has allowed the engineers at the LADPW to expand the scope to develop portable test systems for use in the field, which greatly simplifies the network testing. A further development is to use the soft-modems to replace the field modems as they become unserviceable.

### Conclusion

The final deployed soft-modems execute on desktop PCs and use the integrated sound card for the I/O. This solution means that the solution is both cost effective and flexible. As a further benefit, the software solution ensures that the modems will never again become obsolete.

Having the full source code for the SigLib DSP library and the additional software developed as part of the contract means that the end user will always be able to make maximum use of re-usability should they wish to add further enhancements and functionality in the future.
References


Numerix would like to thank the LADPW engineering team for their assistance in this project and also with the writing of this case study.